MULTIFACTORIAL EMERGENCY FORECASTING METHODS

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Abstract

Recently, great tragedies have occurred, which are caused by the coincidence of various factors in time and in locations. Failure to take into account the fact that different events will coincide in time and location is an error in the forecasting method, since such situations require the use of parallel data, which we will discuss here. The article gives a specific example of the coincidence of 5 natural geological and hydrometeorological events and shows how a natural disaster could have been avoided using a new forecasting method.

Keywords: forecasting, risk analysis, emergency situation, forecasting methods, expert assessment

I. Introduction

The relevance of the problem is determined by the fact that the modern period is characterized by the development of global problems, potentially leading to emergency situations, both in the natural, man-made, and social spheres. These include global climate change, the permanent growth of the technogenic sphere, the problems of terrorism, the negative phenomena caused by globalization, and others. It is necessary to pay considerable attention to the issues of life safety, technosphere safety, ecology, environmental protection and, in this regard, forecasting of crisis and emergency situations of a natural and man-made nature and their consequences. Planning and making adequate management decisions in the field of ensuring safety, preventing and reducing the consequences of emergency situations is impossible without solving forecasting problems [1].

We consider a new system for predicting the risks of natural processes, which is based, on the one hand, on parallel data [2], and on the other hand, on models for predicting events belonging to different areas, but coinciding with each other in time and locations. In addition, it should be noted that if there are no models of different areas, then experts are used for forecasting, who estimate the risk of certain events in%. When using parallel data, a fairly high reliability of the forecast is obtained, which makes it possible to reduce risks or avoid them altogether.

II. New approach to risk forecasting

The result of predicting the risk of a certain event is to determine when, where and with what (what) characteristics the event will occur. In general, non-parametric methods are often used in risk forecasting, such as the least squares method, which evaluates the accuracy of the forecast. Adaptive methods, autoregressive methods and many other methods are also used. It is also important to use expert forecasting methods, including those based on non-numerical data. Particularly relevant is the development of forecasting methods under risk, based on the use of joint combined economic-mathematical and econometric (both statistical and expert) methods in forecasting models.

Precursors in risk forecasting are those that precede the forecasted event and on the basis of which the forecasting model of this event is built.

When considering the actual task of predicting the risk of a natural event, it should be noted that the precursor is mainly a certain geophysical phenomenon that precedes the occurrence of a natural event. Geophysical precursors (phenomena) include, for example, seismic, hydrogeodynamic, deformational, geochemical, thermal, gravitational, and electromagnetic events. As well as the results of observations obtained by remote monitoring of recently developed satellite technologies, etc.

Forecasting a specific natural phenomenon means determining a sequence of actions aimed at detecting the characteristic features of an event or anomalous changes in various geological and geophysical fields, their joint consideration and analysis in order to determine, for example, in the case of an earthquake forecast, location, time and power. That is, the results of forecasting during an earthquake are the place of the earthquake, the time of the event and its power.

[3, 4] discusses a prediction model specifically for risks. In this case, this means that for the same events, different models are created based on different predecessors, which calculate the risks of an event according to certain indicators for this event. These indicators are: the number of justified and unjustified forecasts and the probability of justification. The probability of justification is calculated for each model and determines how many times the event was predicted and how many times the event actually happened. After that, by calculating the risk coefficients, the justification probabilities of all possible pairs of models are considered, then triples, and the best one is selected [5].

When discussing the hybrid risk prediction model, we proceeded from the fact that there is one predicted event and several models for it. Now consider another situation where there is a risk zone and it is necessary to estimate the risk for a given time interval. Suppose there are models based on different predecessors: : $A_1, A_2, \dots, A_n$. Some of these models can predict the same event, but you need to have a model that belongs to a different area. For example, be geological (models for predicting landslides, floods, determining the danger of natural disasters) or, for example, models for forecasting hydrometeorological phenomena that can be attributed to natural hydrometeorological events. river basins, models for studying current processes on glaciers, and others. If there are no models of different fields, then the expert is engaged in forecasting. We will discuss this process in the next paragraph.

Parallel data (or datasets) are different types of data that influence (or predict) a particular event. For example, parallel data during a particular disaster is a collection of the following data: geological, meteorological and hydrological parameters, historical and current data, including decoded information from satellite, radar and aerial photographs, as well as data obtained as a result of field hydrometeorological / geological surveys. The probability of the appearance of each pattern may be small, but under certain conditions, when there is a coincidence in time and locations, this is already a sign of tragedy.

It is possible to formulate a new algorithm for predicting risk: to assess a specific risk (i.e., a specific place and period of time is determined), models $A_{1,}A_{2,} \dots, A_n$ are considered. Prognostic models of the same event are separated from them and their probability of occurrence is calculated. After the model risk percentages for each forecast are obtained for different types of events, the sum of these risks is calculated. That is, a separate risk is calculated for one type of event, separately for another type of event, separately for a third type of event, etc., but the calculation is made in the same place at the same time, and the final result is the sum of these risks.

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III. Engage experts

The new approach to forecasting assumes that there are at least two industry models that are different from event forecasting models, but if this is not the case, then we use experts. In general, the role of experts in predicting such events is very large, since the information obtained by automatic measurement sensors requires a great deal of knowledge and experience from the event specialist.

If several experts participate in the process, then we calculate the sum of the experts' ratings, divide by the number of experts and calculate the average value.

Systematic research and analysis of problem solving takes on an important role in the evaluation of public relations. There is a need to include expert groups and their knowledge in assessments and analysis, whose subjective data in building models create a new type of uncertainty. In parallel with the classical directions of modeling, the assumption of mixed, phase-probabilistic uncertainty becomes important. In this case, it is necessary to use phase methods of expert knowledge engineering and phase logic along with statistical data analysis, which ensures the construction of appropriate full-fledged automated systems and intelligent assistive technologies.

IV. Example

On August 3 this year, in the municipality of Oni, Georgia, a natural disaster unfolded in the Shovi resort, people died, and several million dollars in damage was received. As a result of a natural disaster, the Shov sanatorium was destroyed - it was covered with several meters of lava. The natural disaster triggered geological and hydrological events at the same time. In particular, in the upper reaches of the river there are 2 glaciers that are melting intensively. There was a lot of rain. All these things went on a rampage and the result was a catastrophe. The data given in the example is taken from the official page of the Environmental Protection Agency [6].

It would be possible to predict the event in question if we used a new risk prediction algorithm. The parallel data on which the models are built are as follows:

1. Average annual air temperature anomalies (see Fig.1).
2. Anomalies in the average annual precipitation (see Fig.2).

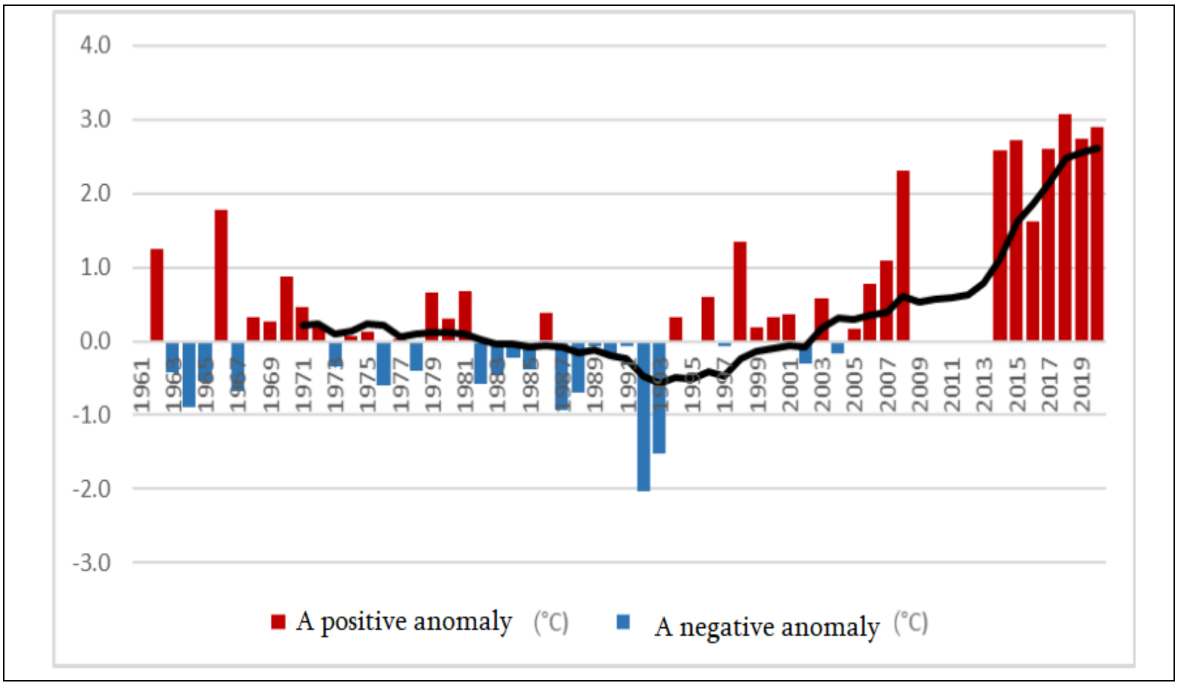

Fig. 1: *Average annual air temperature anomalies (in relation to the period 1961-1990) 1961-2020 for the period and the 11-year moving average*

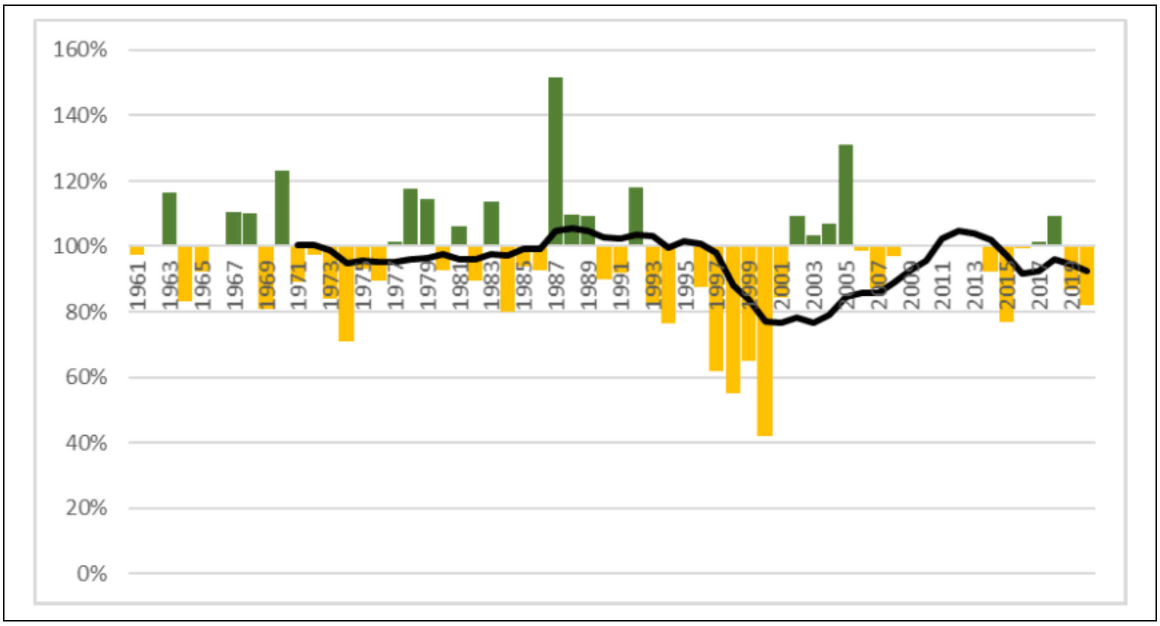

Fig. 2: *Anomalies in the average annual amounts of atmospheric precipitation (in relation to the period 1961-1990) 1961-2017 for the period and the 11-year moving average*

3. Sunshine duration anomalies (see Fig.3):

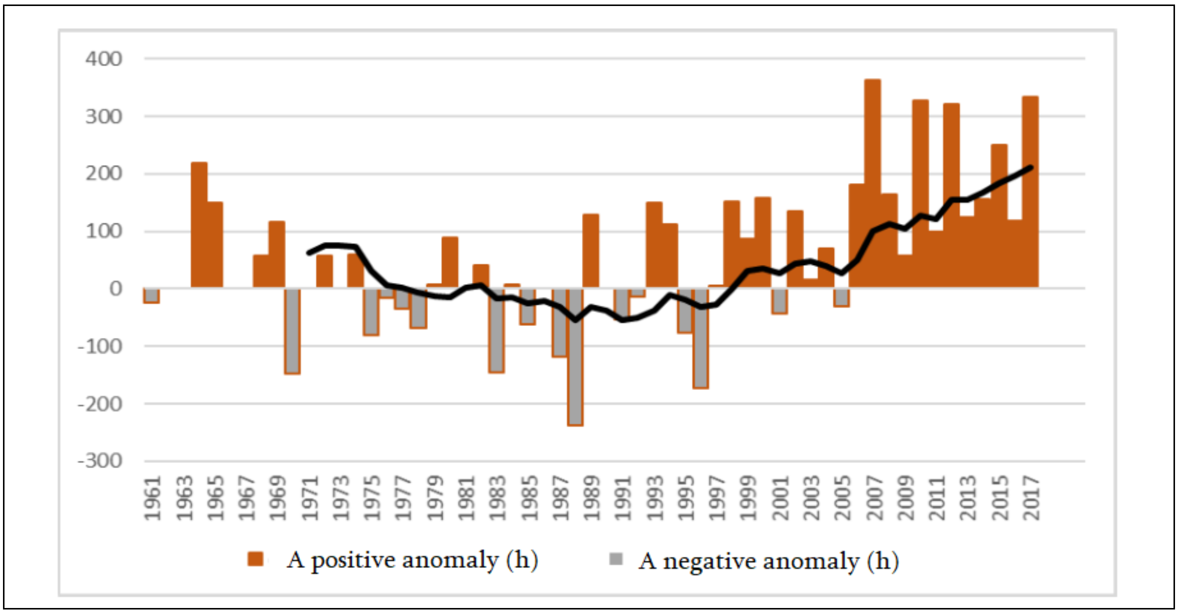

Fig. 3: *Sunshine duration anomalies (relative to the period 1961-1990) 1961-2017 for the period and the 11-year moving average*

The complex geological structure of the valley, seismotectonic conditions, high energy potential of the area (morphological conditions) and climatic changes create a favorable environment for the creation and activation of natural processes in the valley. However, it should be emphasized that until August 3, 2023, b. During the last 100 years, there has been no significant alluvial runoff in the Bubiscali reservoir.

Suppose that there are 5 models of natural geological and hydrometeorological phenomena. Each model estimates the risk of a particular event in %. In particular, such phenomena include: intensive melting of the glacier, precipitation in the form of rain, stone avalanches in the upper reaches, landslide-erosion processes and the passage of mudflows. Let's denote the risk assessment models for these events as A_1, A_2, A_3, A_4, A_5 respectively.

For each model, risk probability values should be calculated. These values are given in Table 1. These values are in the interval [20÷40].

Table 1: A_1, A_2, A_3, A_4, A_5 *model risk probabilities*

Models	Probability of success in %
A_1	38.9
A_2	30.2
A_3	20.5
A_4	27.8
A_5	23.6

The expert involved in the forecasting process analyzed the information obtained from the results of the observation (see Fig.4):

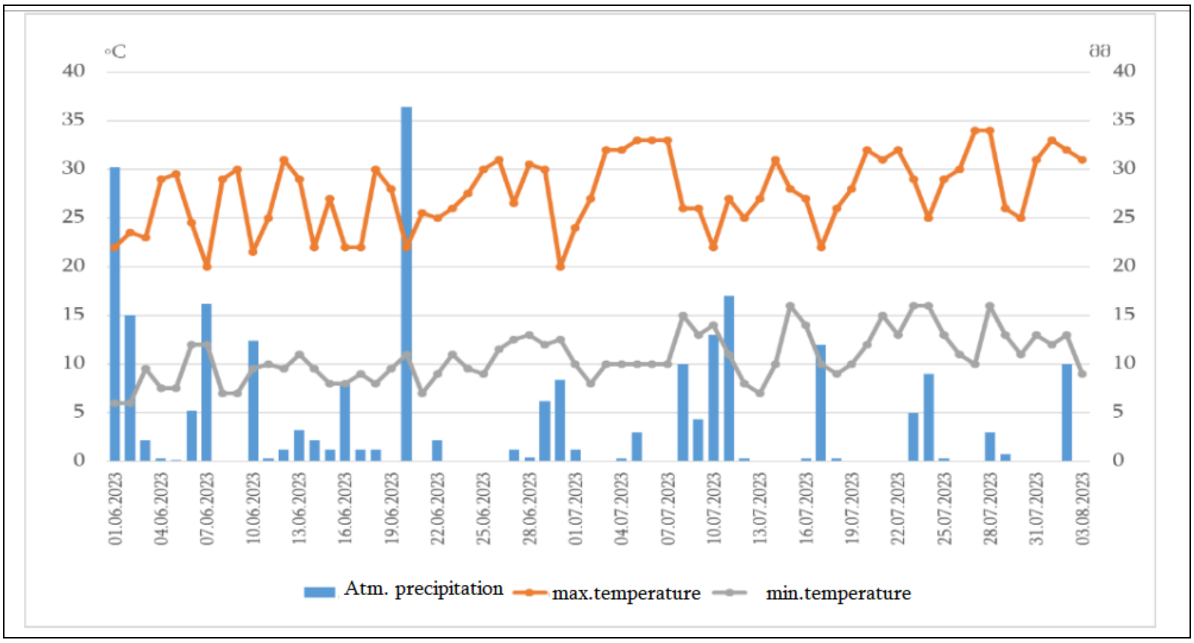

Fig.. 4: *Maximum and minimum air temperatures and precipitation for the period 01.06-03.08 2023, Shovi*

It is worth noting the fact that, based on the analysis of data from a hydrological station (an automatic water flow meter) on the Chanchakh River, the river. There was no prolonged water stagnation in the Bubisskali valley either before the disaster or during the development of the disaster (see Fig.5):

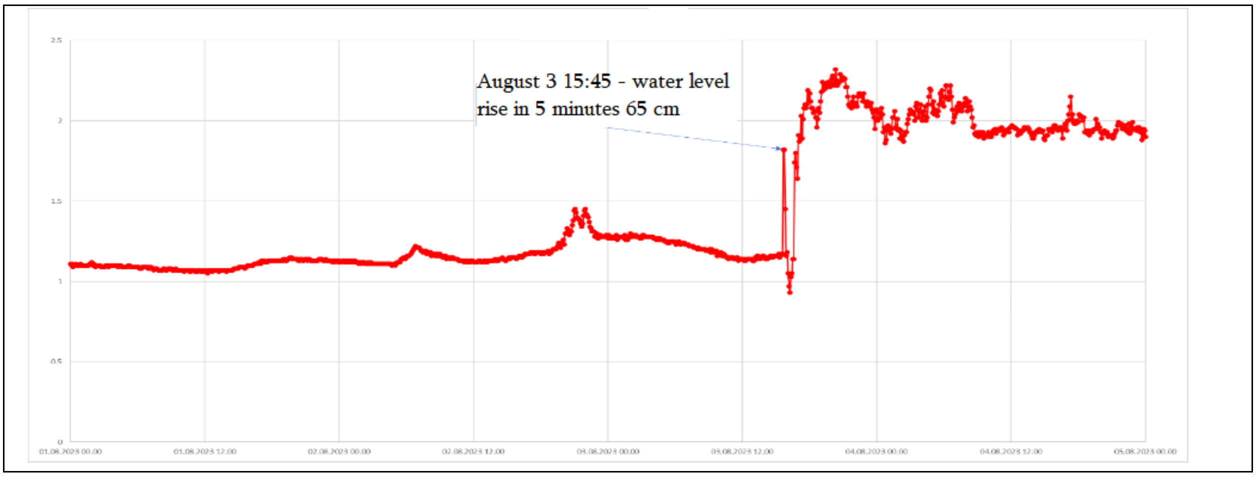

Fig. 5: *Maximum water level (at the mouth of the Chanchakhi River, Rion River) and atmospheric precipitation (given) in the period 01.06-03.08.2023*

The expert's conclusion about a sufficiently high hazard risk is based on the fact that all geological and hydrometeorological events coincide in time and occur in the same area, although each forecast gave a relatively low percentage of risk (from 20% to 40%) even under these conditions (combination in time and space) already necessitates a risk - a tragedy is expected. The sum of risks of various events already exceeds 100%

V. Conclusion

We need a new approach to risk measurement because the existing models are outdated and do not serve the purpose for which they are intended.

The article considers a new model for predicting the risks of natural phenomena based on parallel data. He is in the same place and at the same time, and all these factors increase the risk of a natural disaster.

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