The general structure analysis of avalanche (mudflow) risk assessment

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ABSTRACT. The basic structure of risk assessment is studied. The general form of the assessment formula consists of three components - temporal, spatial and anthropogenic ones. The role and contribution of these components are considered from standpoint of two approaches small- and large- scales (in mapping sense too).The quantative evaluation of contributions is made on the example of avalanche (mudflow) risk assessment for highroad in the Elbrus vicinity. We concluded the most important temporal component may vary from 10^{-6} and less to approx.1 according to used and observed data and consideration scale. So this component becomes comparable with a spatial probability in order. So in the first case we have a background, smoothed assessment of small-scale analysis. In the second one we get a concrete or specific dated (predicted) risk for the real situation by large-scale consideration. In some cases the latter assessment may significantly exceed the former. So we suggest the corresponding term for this risk kind to include in general risk classification scheme.

INTRODUCTION

Let us consider the generally accepted at the present time basic form of risk formula for natural hazards in that number for avalanches and mudflows (Andreev, 1992; Bohnenblust, 1987; Korobkov, 1995; Salm, 1986). Namely, risk R is a product of catastrophe (C) probability P(C) and possible consequences (losses) L(C)

$$R=P(C)L(C) \qquad (1)$$

Going farther we like other authors (Anlreev, 1992; Ragozin A.L.) concluded above-mentioned formula for risk assessment may be structurized as a rule next way:

$$R=R_t\, R_s\, R_a \qquad (2)$$

Here R_t - temporal risk component, expressing the event (of avalanche or mudflow release) probability tied with avalanche (mudflow) occurrencies, R_s is so called geometrical probability, reflecting avalanche paths concentration on hazardous territory and finally R_a - anthropogenic component reflects intensity and extensity of human activity and possible losses because of falling into avalanche (mudflow) impact zone.

Farther for simplicity we use only term avalanches, meaning and mudflows. Besides for visuality and numerical assessment examples we take the avalanche risk assessment for roads (Andreev, 1997).

THE TEMPORAL AND OTHERS COMPONENTS ANALYSIS

The most important component in the above-mentioned structure is R_t from point of view of assessment complication and its significance. From the very beginning here two approaches are to be distinguished as the- macrostatistical = small scaled and predictive = large scaled ones. Some combination of two these may represent also medium-scale approach. For the small-scale analysis an event probability philosophy rises to the foreground. On one hand avalanche release probability may be considered as increasing with accumulation of non-release events. It is hypothesis with determining probabitity of pulling out for example, a white ball out of box with some number of black and white balls upon condition of its non-returning back. On the other hand an avalanche release probability may be considered one and the same i.e. independent based on hypothesis with tossing a coin. From our viewpoint such a choice between two hypotheses is in spite of seeming simplicity of problem is controversial question and apparently immanent to the time flow nature. But the choice of the former hypothesis leads to conclusion of risk increase with time.

The same we can see as to geometrical probability for car driving along the road under avalanche hasard. Then a risk is summed and increases.

Consideration a risk problem on small-scale or medium-scale level is important first of all for economics and insurance purposes. In that case we get some background, spreaded indicators. For example on the highroad section Terskol-Azau in Elbrus vicinity in the Caucasus the risk is assessed approx. 4×10^{-2}

fatalities/year i.e. 4 fatalities in 100 year (1 car in 100 year) (Andreev, 1997). Going to large-scale approach the risk assessment problem comes to plane of a priori and a posteriori probabilities on which the prediction model is constructed. Here the impulsive risk nature plays main role. Using a prediction function we may see at several time periods the temporal risk component increases up to 80 % and higher (due to verification degree of prediction) (Andreev, 1984; Metodicheskie..., 1990). The concidence of a spatial car positions and peak of antropogenic component caused by traffic increase results in significant rise of risk. It is possible while great tourists and sciers flow to mountain resorts in winter season rises, when car flow concentrates in clusters. etc. Then an avalanche risk may exceed background (small-scaled) one several times and reach to tens fatalities.

Now we consider a priori risk assessment. Let us assume on given day in given avalanche path an avalanche must release. By it passing for 1 - 2 min. along the path its release probability is (1 - 2 min.)/1440 min. ≈ 10^{-3}. Because any type avalanches may by repeated in this path not more frequent than one time in 2 days, so we have the order of probability for day 0,5 x 10^{-3}. Besides from observation data (Khibiny, 1959-1980; Elbrus vicinity, 1969-1980-etc.) is known that during whole avalanche hazard period (~200 day in year) the number of days with avalanches varies from 20 to 60. So the probability of avalanche release on any day of avalanche hazard period decreases once more (3 - 10) times and it will be ~10^{-4}. But usually the concrete avalanche path is featured by occurences not more frequent than from only several times in the year to even one time in some years. So we get a probability of order 10^{-5} - 10^{-6}. But when we have several avalanche paths along the road, so we must include to the temporal risk component the probability of synchronized avalanches releasing. That decreases once more a temporal component value. Now let us remind of a geometrical probability. For example, in Elbrus vicinity its order is 0,6 on the road section Azau-Terskol (a hazardous part ~1,5 km, the whole distance ~2,5 km) (Andreev, 1997).

So we see the geometrical probability orders exceeds temporal one. And two these risk components are modulated essentially by anthropogenic one, without which the risk concept itself were not existed. By large-scale assessment in the real hazard situation with using prediction formulae the temporal component may approach geometrical one by order and even to exceed it.

CONCLUSION

Resuming we must distinguish background risk assessment as medium weighted, by the avalanchhe hazard period and "specific dated" value, assessed by prediction method. And the latter may much times exceed the former depending on situation. So we suggest to include in the elaborated present risk and its assessment classification such a term as "specific dated" risk or something of this sort. We would remind that at present time in the risk research field there are next risk categories, kinds and elements (Bohnenblust, 1987; Kuz'min, 1995; Ragozin, 1995) which may relate to avalanche (mudflow) risk too; Namely: ecological, substantial, material, economic, social, complete - integral - partial - elemental, direct - indirect, restorable - unrestorable, accepted - unaccepted, forced: individual - collective, pointed - spreaded, discrete - continuous, short-term- long-term ones. To this two latter categories is possible to include for precising our specific dated risk for some definite time monent (period).

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