



## Avalanche risk assessment in Russia

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The avalanche prone area covers about 3 million square kilometers or 18% of total area of Russia and pose a significant problem in most mountain regions of the country. The constant growth of economic activity, especially in the North Caucasus region and therefore the increased avalanche hazard lead to the demand of the large-scale avalanche risk assessment methods development. Such methods are needed for the determination of appropriate avalanche protection measures as well as for economic assessments during all stages of spatial planning of the territory.

The requirement of natural hazard risk assessments is determined by the Federal Law of Russian Federation. However, Russian Guidelines (SP 11-103-97; SP 47.13330.2012) are not clearly presented concerning avalanche risk assessment calculations.

A great size of Russia territory, vast diversity of natural conditions and large variations in type and level of economic development of different regions cause significant variations in avalanche risk values. At the first stage of research the small scale avalanche risk assessment was performed in order to identify the most common patterns of risk situations and to calculate full social risk and individual risk. The full social avalanche risk for the territory of country was estimated at 91 victims. The area of territory with individual risk values lesser than  $1 \times 10^{-6}$  covers more than 92 % of mountain areas of the country. Within these territories the safety of population can be achieved mainly by organizational activities. Approximately 7% of mountain areas have  $1 \times 10^{-6} - 1 \times 10^{-4}$  individual risk values and require specific mitigation measures to protect people and infrastructure.

Territories with individual risk values  $1 \times 10^{-4}$  and above covers about 0,1 % of the territory and include the most severe and hazardous mountain areas. The whole specter of mitigation measures is required in order to minimize risk. The future development of such areas is not recommended.

The case studies of specific territories are performed using large-scale risk assessment methods. Thus, we discuss these problems by presenting an avalanche risk assessment approach on example of the developing but poorly researched ski resort areas in the North Caucasus. The suggested method includes the formulas to calculate collective and individual avalanche risk. The results of risk analysis are shown in quantitative data that can be used to determine levels of avalanche risk (acceptable, admissible and unacceptable) and to suggest methods to decrease the individual risk to acceptable level or better. It makes possible to compare risk quantitative data obtained from different mountain regions, analyze it and evaluate the economic feasibility of protection measures.

At present, we are developing methods of avalanche risk assessment in economic performance. It concedes costs of objects located in avalanche prone area, traffic density values and probability of financial loss.