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Reliability Analysis of a Glacier Lake Warning System Using a Bayesian Net

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Beside structural mitigation measures like avalanche defense structures, dams and galleries, warning and alarm systems have become important measures for dealing with Alpine natural hazards. Integrating them into risk mitigation strategies and comparing their effectiveness with structural measures requires quantification of the reliability of these systems. However, little is known about how reliability of warning systems can be quantified and which methods are suitable for comparing their contribution to risk reduction with that of structural mitigation measures.

We present a reliability analysis of a warning system located in Grindelwald, Switzerland. The warning system was built for warning and protecting residents and tourists from glacier outburst floods as consequence of a rapid drain of the glacier lake. We have set up a Bayesian Net (BN, BPN) that allowed for a qualitative and quantitative reliability analysis. The Conditional Probability Tables (CPT) of the BN were determined according to manufacturer's reliability data for each component of the system as well as by assigning weights for specific BN nodes accounting for information flows and decision-making processes of the local safety service.

The presented results focus on the two alerting units 'visual acoustic signal' (VAS) and 'alerting of the intervention entities' (AIE). For the summer of 2009, the reliability was determined to be 94 % for the VAS and 83 % for the AEI. The probability of occurrence of a major event was calculated as 0.55 % per day resulting in an overall reliability of 99.967 % for the VAS and 99.906 % for the AEI. We concluded that a failure of the VAS alerting unit would be the consequence of a simultaneous failure of the four probes located in the lake and the gorge. Similarly, we deduced that the AEI would fail either if there were a simultaneous connectivity loss of the mobile and fixed network in Grindelwald, an Internet access loss or a failure of the regional operations centre. However, the probability of a common failure of these components was assumed to be low.

Overall it can be stated that due to numerous redundancies, the investigated warning system is highly reliable and its influence on risk reduction is very high. Comparable studies in the future are needed to classify these results and to gain more experience how the reliability of warning systems could be determined in practice.