AVALANCHE PREDICTION AND STRENGTH-OF-KNOWLEDGE ASSESSMENT

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ABSTRACT: The NGI provides local avalanche forecasting, produces hazard maps and acts as an advisor for national and local authorities during emergencies. A main task is often to assess the likelihood of an avalanche reaching specific objects in a given time frame. These assessments are important input for risk management for settlements, roads and other infrastructure.

This paper contains some preliminary reflections in connection with proposed and ongoing projects at the NGI concerning the categorizing and communication of the quality of knowledge in the context of avalanche prediction.

KEYWORDS: Avalanche prediction, risk management, knowledge assessment.

1. INTRODUCTION

Avalanche prediction is about risk management. For a definition of risk management in this context, McClung (2014) gives an overview of the general structure of risk management that corresponds to established practices in natural hazards.

A recent shift in thinking about risk has been that uncertainty is now more commonly seen as part of the definition, see for example the ISO 31000 standard where risk is defined as the “effect of uncertainty on objectives”. As a consequence, focus is increasingly placed on the background knowledge, or the lack of such knowledge, compared to more traditional probability based perspectives (Aven and Zio, 2017). Risk in this context can be expressed as $p=P(A|K)$, where P is the probability of an event A. This probability contains subjective judgements by the analysts (i.e. experts) which is based on their background knowledge K. Thus the risk description is conditional on K. The "quality" of the knowledge referred to as the "Strength of Knowledge" (SoK). The knowledge may apply to both case information and base-rate data, and may consist of a combinations of standard uncertainty measures that are supplemented with qualitative SoK assessments.

In the risk management perspective, decision makers need to take SoK into account to assess the quality of the predictions, and to make relevant decisions. This also applies to avalanche forecasting and consultancy.

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One example where the need to include the knowledge dimension was highlighted was the aftermath of the 2017 avalanche in Longyearbyen, Spitsbergen. The avalanche caused the destruction of two occupied boarding houses, luckily without fatalities. One of the conclusions from the accident investigation report was that: *The local warning service needs to [..] take into account the uncertainty in the background knowledge. This uncertainty needs to be communicated better.* (Landrø et al. 2017).

The recent guidelines for avalanche practitioners in Canada, TASARM (Canadian Avalanche Association, 2016) states that: *The quality of knowledge base is the most important factor that affects the performance of assessment/decision aids*.

2. DISCUSSION

It can be argued that judgements are only useful if they can be communicated to the decision makers in a comprehensible way, preferably in quantitative terms (Kristensen, 2014). However, most approaches can be termed semi-quantitative since they attempt to integrate quantitative and qualitative representations. How to best categorize and communicate the SoK for different applications is an ongoing research effort (Aven et al, 2017) and the following is not an exhaustive review of possible approaches.

As examples of contemporary approaches, the well-known matrix used by Intergovernmental Panel on Climate Change (IPCC, 2013) can be mentioned. Here, the confidence in the validity of findings is rated according to the scientific consensus and the quality of evidence.

Systems for knowledge and information management like the DIKW have existed for some time. The DIKW provides a hierarchical representation of the relationships among Data, information, Knowledge and Wisdom and gives an account of the assumptions made together with a rating of their importance (Wallace, 2007).

The risk community in Norway, particularly at the University of Stavanger has been active in exploring these issues for some time. For example, Flage and Aven (2009) have proposed simple schemes for assessing knowledge in different settings. For example, a judgment is made on the knowledge being weak if one or more of these conditions are true:

- The assumptions made represent strong simplifications.
- Data are not available, or are unreliable.
- There is lack of agreement/consensus among experts.
- The phenomena involved are not well understood; models are nonexistent or known/believed to give poor predictions.

If, on the other hand, all of the following conditions are met, the knowledge is considered strong:

- The assumptions made are seen as very reasonable.
- A great deal of much reliable data are available.
- There is broad agreement/consensus among experts.
- The phenomena involved are well understood; the models used are known to give predictions with the required accuracy.

Cases in between are classified as having medium strength of knowledge.

This is somewhat similar to the NUSAP notational scheme (Funtowicz and Ravetz, 1990) aims to categorize the background knowledge for communication of uncertainty in science for policy. The system consists of a pedigree matrix for numerically ranking according to e. g. theoretical structures, experimental data and peer-acceptance. The NUSAP scheme has also been further developed and applied to the risk perspective (Berner and Flage, 2016).

When it comes to the field of avalanche prediction the subject of categorizing knowledge has in a sense been addressed as far back as in the 1970-ies. Ed LaChapelle (1979) suggested classifying strength of evidence in terms of data classes with regards to informational entropy (se also McClung and Schaerer, 2006). Three classes of data are ranked according to the degree of uncertainty reduction they provide.

The TASARM guidelines (Canadian Avalanche Association, 2016) suggest that the background knowledge can be expressed in terms of confidence levels, somewhat in line with the IPCC.

It should be pointed out that strengthening of knowledge on its own does not necessarily lead to risk reduction. The sensitivity to changes in a variable, as well as deviations from the implicit assumptions, may strongly influence the risk.

The developments of NUSAP pedigree scheme notational scheme seem to take these aspects into account to some degree, however. Berner and Flage (2016) propose a presentation format that combines the NUSAP scheme with the assumption deviation effect.

3. CONCLUSION

The demands from risk standards like ISO 31000 and from the decision makers, highlights the need for assessing and communicating the background knowledge and the uncertainties. Decisions frequently have to be made despite incomplete knowledge. Although the question of how decisions should be adapted in the face of this is outside the scope of this discussion, it is clear assessments of the strength of the background knowledge can profoundly influence decisions.

4. CONFLICT OF INTEREST

The author of this paper is an employee of the Norwegian Geotechnical Institute. In addition to research, the institute provides avalanche forecasting services and consulting for natural hazards.

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