TOWARDS AN IMPROVED EUROPEAN AUXILIARY MATRIX FOR ASSESSING AVALANCHE DANGER LEVELS

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ABSTRACT: Since 1993, the European Avalanche Warning Services (EAWS) use a common 5-level Avalanche Danger Scale to describe the regional avalanche danger in public bulletins. In order to ensure a unified and harmonized use of the danger rating, EAWS introduced an auxiliary matrix (Bavarian matrix) in 2005. The matrix represents danger levels given in the European Avalanche Danger Scale according to the release probability and distribution of hazardous sites. Its intention is to ensure a high level of objectivity and consistency among different forecasters and forecasting services in situations that are arbitrary based on the danger scale alone. Currently an EAWS workgroup extends the auxiliary matrix by integrating avalanche size to broaden the applicability of the matrix. The intention is to provide an improved tool that clearly defines each danger level based on the release probability, distribution of hazardous sites, and the size of expected avalanches. We used two different methods to link the three parameters to a danger rating: (i) expert opinion of various forecasters and (ii) data base analyses of several winter seasons. We will present the draft for the updated matrix, explain the concept behind it and its intended application. Further, we give insights into similarities, but also differences to the Conceptual Model used in North America. We will provide a draft-version to all EAWS members prior to winter 2016/2017 in order to test the new concept and collect feedback over one season. The intention is to present a final version by 2017.

KEYWORDS: Avalanche forecasting, Bavarian matrix, EAWS.

1. INTRODUCTION

The avalanche danger level expresses the prevailing avalanche danger for a specific region and time as a single integer. It is the simplest information and shortest abstract to describe a situation and is therefore at the top of the information pyramid (WSL Institute for Snow and Avalanche Research SLF, 2015).The danger level is an integral part of many behavior measures for backcountry skiers or avalanche safety people.

The European Avalanche Danger Scale (EDS) defines five avalanche danger levels (EAWS, 2016a). Each danger level is defined by the prevailing snowpack stability and the avalanche release probability. Other criteria for an avalanche danger level are the typical avalanche size and the spatial distribution of hazardous spots. The scale was introduced as a common European scale in 1993. The rather coarse definitions of the individual terms allow for a certain degree of subjective interpretation. However, regional data is often sparse, allowing for a coarse avalanche danger evaluation, too. However, this room for interpretation leads to occasional inconsistency between neighboring warning services or among forecasters within a service. As a measure to reduce subjectivity and to define each danger level at a finer detail, the Bavarian Avalanche Warning Service introduced a matrix in 2003 (Fig. 1). Versions that are more complex, were discussed at that time, but discarded due to a lack of agreement.

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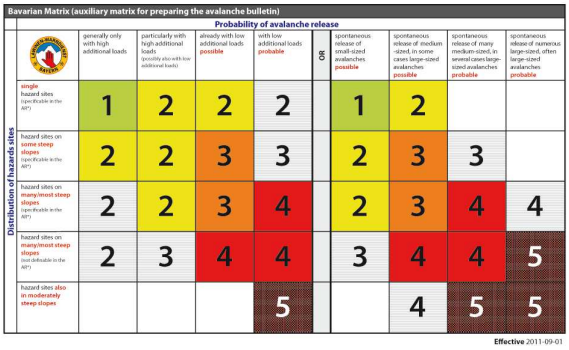

Fig. 1: The EAWS accepted the Bavarian matrix as an auxiliary tool in 2005 (EAWS, 2016b). It is a simplified graphic representation of the definition, but defines situations "in-between" the coarse definition of the EDS. Grey marks cells that not all members have approved, yet. White cells indicate unrealistic scenarios/combinations. The left table applies for human triggered and the right table for natural triggered avalanches.

The European Avalanche Warning Service (EAWS) adopted this matrix in 2005 as the Bavarian Matrix (BM). Despite being in use for over ten years now, some cells are still under discussion today. One reason for that might be the diverse use of the BM among warning services, where some services apply it only occasionally or not at all.

The EAWS General Assembly tasked a workgroup in 2013 to investigate necessary improvements of the BM and EDS, thoroughly.

2. ADAPTION PROCESS

The major drawback of the BM is that avalanche size is not included in its left table concerning human-triggered avalanches and only partially on its right table concerning natural released avalanches (see Fig. 1). E.g. in a situation where it is possible to trigger an avalanche by low additional load on some slopes danger level 3-considerable is suggested, independent the expected avalanches are of destructive size 1 or 4 (the definition describes only the size of spontaneous avalanches, which are typically of size 3 and sometimes of size 4 for danger level 3).

Therefore, a first major step was to integrate avalanche size in the existing BM and to refine the definition of the danger levels. For that purpose, we added sub-cells to each existing cell of the BM (Fig. 2).

Fig. 2: BM cells accommodated to integrate avalanche sizes.

Each work group member had to fill out these cells to get an overview of where we have a general agreement and where we need to work towards such an agreement. This exercise showed that most of the disagreement could be tracked back to different interpretation of the definitions in the BM and EDS.

3. CLARIFYING DEFINITIONS

A first important step in improving the BM is to provide unambiguous definitions of each parameter integral in the BM and/or the EDS. Of the three main parameters,

- Spatial distribution of hazardous sites
- Avalanche release probability
- Avalanche size

Avalanche size is the only one that is clearly defined. Definitions need to be technically correct and unambiguous. However, a need for an easy to grasp and intuitive version is necessary to communicate efficiently with the end-user. That communication includes the reporting of observations by users to the avalanche services too.

4. DESIGN CONSIDERATIONS

In a first step, we used the original design of the BM and integrated avalanche size in it (Fig. 2). We tested two other designs. One splits the matrix into three components, therefore dubbed "Matrix3". The intention is to have a layout that resembles the workflow of an avalanche forecaster and to illustrate clearly snowpack stability and the distribution of hazardous sites (Fig. 3).

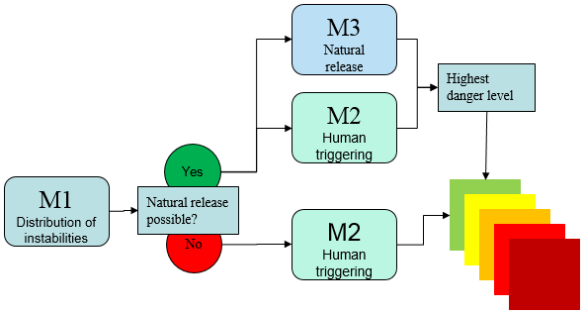

Fig. 3: The Matrix3 approach splits the BM in three matrices and resembles the assessment process of an avalanche forecaster.

The third design is a compact version of the Matrix3. The intention is to streamline all components and reduce complexity.
An analysis of more than 4600 avalanche assessments made by Norwegian forecasters and a survey conducted among the Swiss forecasters, showed that the Matrix3 is less conservative compared to the BM. That is similar conditions would occasionally assigned a lower danger level when using the Matrix3 (including avalanche sizes) than when strictly adhering to the BM.

5. COMPARISON TO THE NORTH AMERICAN DANGER SCALE

A group of North American avalanche experts revised the EDS in the period 2005 to 2010. They state, “The first and foremost purpose of the avalanche danger scale is public risk communication“(Statham et al. 2010). Therefore, the North American Danger Scale (NADS) favors a simpler and clearer language. The conceptual model of avalanche hazard (CMAH) is a result of the revision. It describes avalanche hazard assessment as a systematic workflow that starts from individual field observations, moves through a step-wise assessment of individual hazard components, combines them using a risk-based framework, and then concludes with a hazard assessment factoring uncertainty (G. Statham, pers. comm.).

We had a close look at the definitions provided within the CMAH and compared them where applicable. Terms to describe the spatial distribution of hazardous sites are similar between the two concepts. The avalanche size classification is identical, except the naming convention. The CMAH uses the same size classes 1-5, but divides only in three classes (small, large, very large) when using avalanche size in a textual context.

The major differences between the BM and the CMAH are with regard to the usage of snowpack stability and terms/ for additional loading or triggering. Snowpack stability takes up the first column of the EDS, but is not an explicit part of the BM. In the CMAH and NADS, snowpack stability is not mentioned explicitly, but rather defined by the sensitivity to natural- or human-triggered avalanches. The BM describes the probability of human triggering as a combination of the probability terms *possible* and *probable* and the classes *high* and *low* addition loading. The CMAH uses only the term *human-triggered* (combining high and low additional load), but uses four classes of sensitivity: unreactive, stubborn, reactive, and touchy (CAC, 2016). The CMAH concludes with a so called “avalanche hazard chart”, but does not suggest a danger level explicitly.

Travel advices are not common in all European countries. Some countries abstain from that knowingly.

6. FURTHER PROCEDURE

We are currently writing the guidelines for the updated matrix. We will publish the updated BM together with the guidelines on www.avalanches.org in November. The idea is that all avalanche services test the updated matrix during the coming season (2016/2017) and we will collect feedback towards the end of the season. A final version is planned prior to the General Assembly in 2017.

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