How big is big: results of the avalanche size classification survey

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ABSTRACT

Avalanche size is a key parameter in avalanche danger rating as well as in the communication between technicians. In 2009 the European Avalanche Warning Services (EAWS) adopted the Canadian Destructive Avalanche Size Scale (Perla 1980) but with some changes: for example, the numerical rating used in Canada and the US was substituted by the descriptive terms 'sluff', 'small', 'medium', 'large' and 'very large'. In 2010 an additional column was introduced in order to include the characteristics of the avalanche runout.

To evaluate the uniformity in the use of the said scale, a survey questionnaire was sent out to all the EAWS avalanche centers and to different avalanche services in Canada. It comprised 18 avalanche cases with pictures, maps and basic morphological data. At the moment of performing this analysis, 70 surveys have been received back, 61 of which from 10 different European countries and 9 from Canada. Basic statistical description is hereby performed, including Mode, Mean and Standard Deviation.

The results of the survey show a lack of uniformity in the classification of avalanche sizes within and between EAWS centers. In comparison, Canadian results are much more uniform. The cause of this lack of standardization in the European centers seems to be the absence of guidelines on how to use the scale as well as the additional parameters that were introduced in the European scale. The results of this survey are currently being used to improve the avalanche size scale used by the EAWS.

KEYWORDS: Avalanche size, survey, EAWS.

1 INTRODUCTION

The Avalanche Destructive Size Scale was first introduced in the U.S. by M. Atwater (U.S.D.A., 1961, rev. 1968). After Perla introduced it in Canada in 1977, it was adopted and extended by the Canadian Avalanche Committee. McClung and Shaerer reviewed and improved the size scale, by estimating the mass of 744 observed avalanches at Roger's Pass, BC., and calculating or measuring the impact pressures of the observed avalanches. This resulted in a robust avalanche size classification that has been used for the last 30 years without any changes in Canada, New Zealand and the U.S.

In Europe, the EAWS adopted the Destructive scale in 2009 with some minor changes. In 2010 a new parameter was introduced -"*Runout Classification*"- leaving the scale with 4 parameters: *Avalanche Destructive Potential, Runout Classification, Typical Length* and *Typical Volume.* The main differences with the Canadian Scale are the use of *Volume* instead of *Mass* and the introduction of the *Runout Classification* parameter (Figure 1).

Obviously, avalanche size is a key parameter both when communicating with the public (i.e. in the public advisories) and when transmitting information between professionals (i.e. avalanche reports from observers). Avalanche size is used in the European Avalanche Danger Scale when determining the avalanche danger level due to spontaneous releases, and is used extensively in the Bavarian Matrix.

The above avalanche size scale has been used by the avalanche services operating in the Pyrenees for the last two seasons, 2011/12 and 2012/13. Conscious of the importance of uniformity when it comes to rating, we decided to carry out a survey amongst the EAWS warning services in order to spot any possible differences and find the possible causes of discrepancy.

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2 THE SURVEY

By the end of the 2012-2013 season a survey was designed and sent out. It comprised 18 avalanche cases including one or more pictures, a map in an appropriate scale and a few parameters (avalanche length, avalanche width, crown thickness mean and maximum and consequences if any). We decided not to include more detailed parameters (like volume/mass of debris, thickness of the debris or others) because often they are not available when classifying an avalanche in a real operation.

EUROPEAN DESTRUCTIVE SIZE SCALE

Size	Avalanche destructive potential	Runout classification	Typical length	Typical volume
1 Sluff	Relatively harmless to people with minimal danger of burying (danger of falling).	Snow relocation stops typically before the end of a slope.	10 m	100 m3
2 Small	Could bury, injure or kill a person.	Stops typically at the end of a slope.	100 m	1000 m3
3 Medium	Could bury and destroy a car, damage a truck, destroy small buildings or break a few trees.	Could traverse flat areas (considerably below 30º) over distances of less than 50 m.	1000 m	10.000 m3
4 Large	Could destroy a railway car, large truck, several buildings or a piece of forest.	Traverses flat parts (considerably below 30º) over distances >50 m and can reach valley ground.	1-2 km	100.000 m3
5 Very large	Could gouge the landscape. Disastrous damage potential possible.	Reaches valley ground. Largest snow avalanche known.	3 km	>100.000 m3

Figure 1. Avalanche size scale used in Europe. In red, the differences between the European and the American scales.

The criteria for the choice of the avalanche cases were:-

– Availability of a clear picture and a detailed mapping.

– Presence of the 5 types, with more cases at the centre of the scale (sizes 2, 3 and 4).

– Some of the cases were chosen with a specific aim: case 7 -large mass/volume with short length and low energy; case 17 -in the lower end of what can be considered an avalanche; case 18 -a very long avalanche with little snow entrained.

The participants were asked to classify the 18 cases, using the 5 integer values and using the intermediate values (.5) that are common in Canada. They were also asked to indicate in each case which was the main parameter for their classification.

The survey was sent initially to the avalanche services pertaining to the EAWS and in charge of public forecasts, which means 12 countries with different internal organizations. They were asked to fill in one survey per forecaster, without previous internal discussion. 61 surveys were sent back from 10 different countries. At a later stage we decided to extend the survey to Canada and the U.S. with the aim of comparing the standardization of the size classification in both sides of the Atlantic. The survey was sent to the forecasters at the Canadian Avalanche Centre, and a link to the survey was included in the Canadian Avalanche Association newsletter. This took place by the end of the season, when most of the professionals had already turned to their summer duties, and so far only 9 surveys have been received back.

3 DISCUSSION

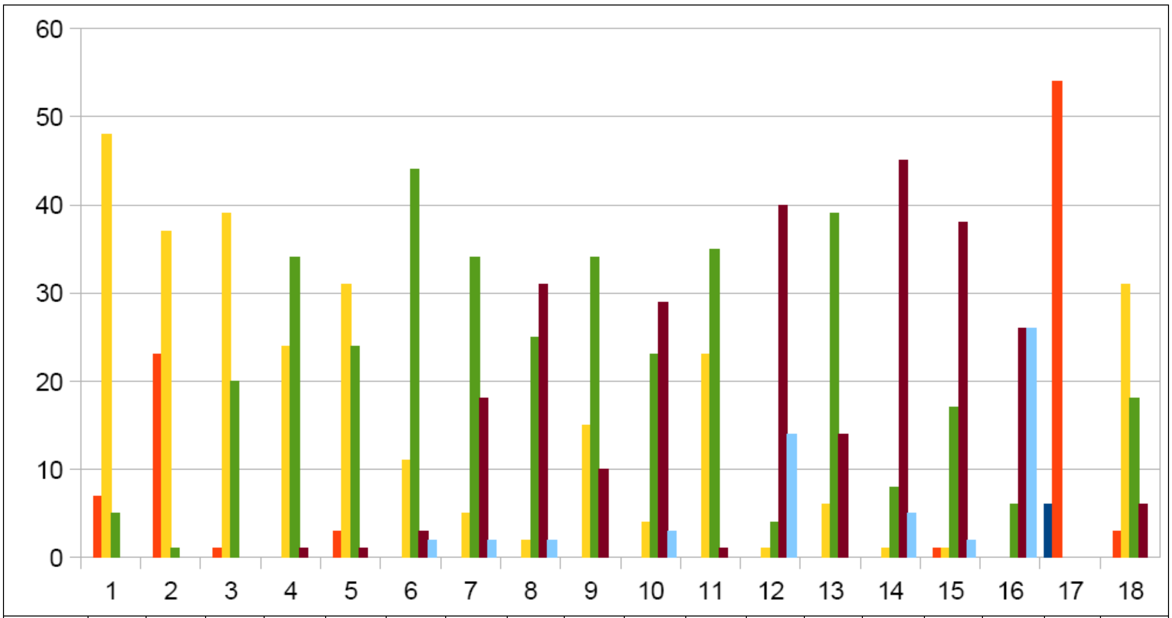
We review here the main features of the sample. For comparison purposes, we often split the sample in two groups: European (n=61) versus Canadian (n=9) surveys. These two groups are not balanced in number, so the results are not definitive. We have taken into account all the surveys received, not only the ones coming from forecasters. Service coordinators, professional field technicians, researchers, students and instructors are also included in the sample. In some cases the sample is broken down by country, but the number of surveys per country is only significant (n>9)for Austria, Catalonia, Romania and Canada .

For a general description of the survey results, Figure 2 plots the avalanche size categories chosen for the 18 cases, using only the integer values (not the intermediate) and including all the European surveys. These categories are accompanied by a few statistical parameters that help to describe the sample.

The homogeneity in the use of the scale by the European professionals could be shown by the percentage of agreement, that is to say, the number of surveys that put each case in the same category. This agreement varies widely, from 90% in the best case, to less than 50% in the worst cases. The average agreement of the 18 cases is 62% whereas in the Canadian sample the maximum agreement is of 100% and the minimum 56%, with an average of 81%.

Another measure of the homogeneity is the range of categories used by different observers to classify the same case. In the European data this goes from 2 in the best case (it is case 17, a very small snow movement, hardly an avalanche) to 5 in the worst one, which means that one same case is classified in every possible different category in the scale. The average range is 3.5. In the Canadian results, the range goes from 1 to 2, with an average of 1.8.

Finally, Standard Deviation (SD) is considered in order to measure the dispersal of the results. Having a sample with values in a small range (0 to 5) this parameter is able to describe how close the classifications from the different



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mode	2	2	2	3	2	3	3	4	3	4	3	4	3	4	4	5	1	2
% Mode	80,3	59	62,3	57,4	50,8	72,1	55,7	50,8	57,4	49,2	59	68,9	67,2	78,7	65,6	45,9	90,2	49,2
Rank	3	3	3	3	4	4	4	4	3	4	3	4	3	4	5	3	2	3
SD	0,44	0,52	0,51	0,52	0,61	0,56	0,65	0,59	0,65	0,69	0,52	0,59	0,56	0,5	0,64	0,67	0,3	0,8
%col1	40,4	32,7	33,3	33,3	25	38,5	32	21,2	35,3	25	39,2	65,4	19,2	43,1	32	29,4	36,7	28,8

Figure 2: Representation of the results of the European surveys. N=61. In colours, the % of surveys that classified each avalanche in that particular size category (dark blue: no avalanche; orange: size 1; yellow: size 2; green size 3; purple: size 4; light blue: size 5). Below, the Mode (value most chosen), % of agreement in the mode (how many surveys agree in this value), the rank (how many different values are used in the surveys), and the percentage of surveys that use the *Destructive Potential* as the main parameter for their classification.

surveys are. In the results coming from Europe, and not taking into account case 17, SD varies between 0.44 and 0.67, with an average of 0.59. In the surveys coming from Canada, SD goes from 0 to 0.5, with an average of 0.31. Figure 3 shows the average SD plotted by country. Wide differences are observed, even when only taking into account the countries with a significant amount of surveys .In the survey, the professionals were asked to classify the avalanches using the intermediate values commonly expressed as .5 values. Many European surveys were returned without having filled in this field. An improvement of the SD average is observed in the cases where intermediate values are used: they range from 0.57 to 0.48 but the average agreement (the number of surveys whose answers coincide) is reduced from 67% to 25%. This is easily explained by the enlargement of the scale, that passes from 5 to 10 values. In Canada the SD is reduced similarly from 0.31 to 0.27, but the average agreement is reduced only from 81% to 64%

Looking for the causes of the different results obtained for Europe and Canada, we plot in

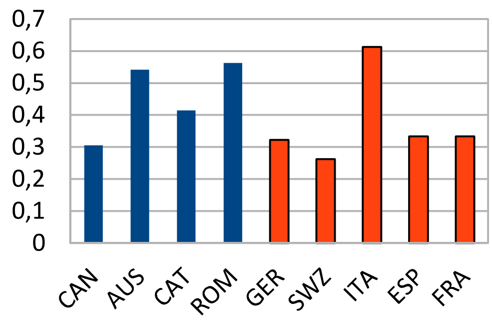


Figure 3: Standard deviation values plotted by country. In blue, the countries with 9 or more surveys, in orange countries with 2 to 4 surveys.

figure 4 the use of *Destructive Potential* as the main classification parameter. The dispersal in the European surveys is visible. In these cases *Destructive Potential* is preferred (34%), but closely followed by *Typical Volume* (27%) and with relevant uses of *Runout Classification* (20%) and *Typical Length* (19%). In the Canadian surveys the results are much more concentrated in the *Destructive Potential* (72%)In order to find trends in the survey results, we calculated what we call the *Estimation Ratio.* This ratio shows if the answering professional tends to overestimate (>1) or underestimate (<1) the size of the avalanche cases. In figure 5 we plot the national average for this ratio. Calculating the ANOVA statistic, we found that there exist significant differences between countries.

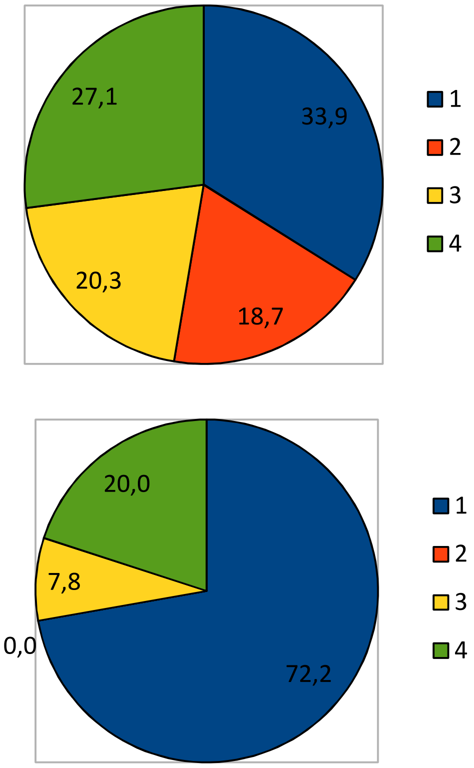


Figure 4: Percentage of application of each of the parameters in the European (top) and Canadian (bottom) surveys. 1: Destructive Potential; 2: Runout classification; 3: Typical length; 4: Typical mass/volume.

4 CONCLUSIONS

All the statistical descriptors used in this study indicate a lack of homogeneity when using the avalanche size scale amongst the European professionals. The agreement percentage is low, only about half of the professionals agree on a particular classification. Moreover, they classify the avalanches in a wide range of size categories (3 or 4 usually). The standard deviation is accordingly high. A proper comparison with the results coming from Canada is not feasible due to the small size of the Canadian sample, but all the indicators

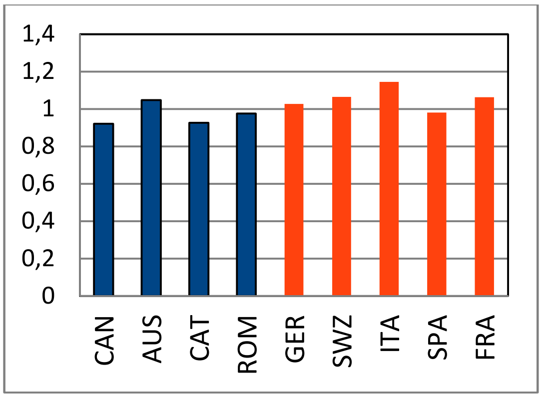


Figure 5: Estimation Ratio per country. This ratio comes from dividing every classification in the survey by the average of the classifications for this case. In blue, countries with 9 or more surveys, in orange countries with 2 to 4 cases.

(agreement, range, SD) are ostensibly more uniform in the Canadian questionnaires.

Although the introduction of intermediate values between the sizes reduces the dispersal of the results, it also reduces the percentage of agreement. Having 10 possible classifications makes it more difficult to have coinciding results, but on the other hand, results can be grouped closer to one another.

The causes for the different results in the surveys from Europe and Canada could be found in the differences in the scale and their use. In Canada there exist a complete and strict set of guidelines on how to estimate the avalanche size (CAA 2007), which specify that the main parameter for the classification should be the *Destructive Potential,* while the others (*Typical Length* and *Typical Mass)* should only be used as an aid in case of doubt. This is reflected in the high percentage of use of the *Destructive Potential* as the main parameter (72%) in the Canadian sample. In Europe, the lack of guidelines and the presence of a fourth column in the scale (*Runout Classification)* lead to a dispersal in the use of the parameters. This fourth parameter is not correlated with the others, and is more similar to the Relative Size Scale used in the U.S. A further difference in the scales is the use of Volume (Europe) instead of Mass (America). Mass seems to be more appropriate, as it is contained in any avalanche dynamics model, and it has been calculated in real cases.

Having all this in mind, and waiting for more Canadian surveys to strengthen or question these conclusions, the results of this survey seem to recommend the adoption of the Canadian avalanche destructive size scale without any changes, including their guidelines. The lack of an homogeneous training could be solved partially with an avalanche size catalogue. The use of the intermediate values should be considered, as well as the introduction of a separate second size scale, the Relative one.

At the moment of publishing this study the European Avalanche Warning Services will have finalised their measures to improve the use of the avalanche size scale. We will try to include them in the poster that accompanies this paper.

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