USING TOTAL AVALANCHE VOLUME TO ASSESS CONSISTENCY IN OPERATION AVALANCHE SIZE REPORTING.

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ABSTRACT: Avalanche size assignments often rely on visual estimates of key parameters such as destructive potential, debris extent, and avalanche mass, all of which are sensitive to inter-rater variability, observer experience, and vantage point. The 2024 update to the Canadian Avalanche Association Observation Guidelines and Reporting Standards (OGRS) introduced a method for estimating avalanche size based on debris volume. However, in practice, Canadian ski operations contributing to the InfoEx dataset rarely report debris depth. Instead, observations more commonly include avalanche length, width, and crown depth, enabling calculation of total avalanche volume rather than deposited debris volume. Given that avalanche size classes are defined on a logarithmic scale, it is reasonable to expect that size categories may still be distinguishable using total volume as a proxy.

This study evaluates the feasibility of using total avalanche volume as a proxy for debris-volume-based size classification and assesses consistency in size reporting within a single guiding operation. At the selected operation, 99 avalanches were recorded between December 2025 and April 2026, of which 71 contained sufficient data to estimate total avalanche volume. Debris depth was not reported for any events. Calculated volumes were used to assign predicted size classes, which were then compared to sizes reported by guides.

In 66 of the 71 avalanches, the predicted size exceeded the reported size, in some cases by as much as two size categories. Despite the logarithmic nature of the size scale, this discrepancy suggests inconsistency in field-based size assignments. Several limitations should be noted: avalanche geometry is often complex and terrain-constrained, making simple volume approximations imperfect, and all input parameters are subject to observational uncertainty.

Overall, these findings highlight the limitations of current observational practices and reinforce the need for more standardized, measurement-based approaches. Encouraging practitioners to record debris depth within InfoEx would enable more accurate debris volume estimates, improve consistency in size classification, and support a better understanding of inter-rater variability in operational avalanche assessments.

KEYWORDS: Avalanche size, Avalanche volume, Avalanche volume deposits

1. INTRODUCTION

Avalanche professionals routinely estimate avalanche size, an important descriptor of avalanche magnitude and potential consequences. In Canada, avalanche size is assigned using the Canadian Avalanche Size Scale, which ranges from Size 1 to Size 5 and is primarily based on destructive potential.

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The scale is intended to describe the potential consequences of an avalanche, with increasing size corresponding to progressively greater potential to injure people, destroy vehicles and structures, and affect larger areas of forest or infrastructure. (Canadian Avalanche Association, 2024)

Although destructive potential is expressed descriptively, the Canadian Avalanche Association's Observation Guidelines and Recording Standards (OGRS) also provide quantitative reference values for several characteristics of an avalanche, including typical mass, typical path length, typical deposit volume, and typical impact pressure. The 2024 OGRS lists typical deposit volumes increasing on a log scale of 50, 500, 3,000, 25,000 and 200,000 m³ for Sizes 1 through 5, respectively. The OGRS notes that the deposit-volume estimates were derived from estimated mass and that further research is required to confirm them (Canadian Avalanche Association, 2024).

An important consideration when interpreting differences in avalanche size is that the size scale is approximately logarithmic rather than linear. The numerical difference between Size 2 and Size 3 is only one unit, but the corresponding difference in the physical characteristics of the avalanche is substantially larger. The CAA's typical deposit volumes increase from approximately 50 m³ for Size 1, to 500 m³ for Size 2, 3,000 m³ for Size 3, 25,000 m³ for Size 4 and 200,000 m³ for Size 5.

Consequently, an increase of one avalanche size represents an approximately order-of-magnitude or near-order-of-magnitude increase in the typical volume of deposited snow, rather than a simple incremental increase. Thus although calculating the volume of an avalanche from the crown depth, width and length alone is likely a larger number than the avalanche deposit volume, it is reasonable to think it may be within that order of magnitude difference.

Avalanche size has historically also been related to slab depth. McClung (2009), for example, demonstrated relationships between measured slab dimensions and avalanche volume and mass, and showed that slab depth can provide a useful basis for estimating the amount of snow potentially released. However, the relationship between slab dimensions and avalanche size is highly variable. In a dataset containing both measured and estimated avalanches, the ratios between width, length and slab depth varied over several orders of magnitude (McLung, 2009)

There is also evidence that human estimates of avalanche size have substantial variability. Hafner et al. (2023) evaluated avalanche-size estimates made by 170 avalanche professionals in Europe and North America. The most frequently selected size agreed between observers for approximately 66–67% of observations, while agreement with the study's reference size was approximately 74%. The authors concluded that the reliability of avalanche-size estimates is limited and that this uncertainty should be considered when such data are used.

The Canadian avalanche industry already collects several measurements that could potentially be used to develop such an approach. Within InfoEx, avalanche observations commonly include avalanche length, width and crown depth. Although these parameters are not themselves a formal method for calculating avalanche size, they provide an opportunity to investigate whether an easily calculated geometric proxy is associated with practitioner-assigned avalanche size.

2. METHODS

2.1 Data source and avalanche selection

A single avalanche operation was selected from InfoEx based on the authors' familiarity with the operation and its terrain. This allowed the dataset to be reviewed for obvious measurement errors and inconsistencies. The operation has been kept anonymous.

Using the InfoEx search filters, all avalanches reported between December 1, 2025 and April 15, 2026 were identified. This period extended at least seven days before and after the operation's active reporting season to reduce the possibility that observations from the beginning or end of the operating season were excluded.

A total of 99 avalanches were reported during the study period.

2.2 Data extraction

The avalanche observations were transferred to a spreadsheet and organized chronologically. Each observation was manually reviewed.

An observation was considered complete for the purposes of this analysis if it contained:

- practitioner-assigned avalanche size;
- avalanche width (m);
- avalanche length (m); and
- crown depth (cm).

Observations missing any of these parameters were excluded from the quantitative analysis.

All measurements were converted to meters. Crown depths, which were commonly recorded in centimeters, were converted to meters.

Where a range was recorded for a measurement, the midpoint of the reported range was used as the representative value.

2.3 Calculation of geometric volume proxy

For each complete observation, width, length and crown depth were multiplied:

$$Vproxy = W \times L \times Dcrown \quad (1)$$

where:

- W = recorded avalanche width (m);
- L = recorded avalanche length (m); and
- D_{crown}= recorded crown depth (m).

This calculation produces the volume of a rectangular prism defined by the three recorded dimensions.

2.4 Assignment of avalanche size from the volume proxy

The calculated geometric volume proxy was compared with the typical deposit volumes published in the 2024 CAA OGRS:

Avalanche size	Typical deposit volume (m³)
1	50
2	500
3	3,000
4	25,000
5	200,000

Table 1: Avalanche size with typical deposit volume listed in the 2024 OGRS

Because the purpose of this analysis was to investigate how a numerical volume proxy might be translated into a size classification, two different classification conventions were examined.

2.5 Classification method 1: Whole-size thresholds based on stated size

The first method treated the published typical deposit volumes as boundaries between size classes. Under this convention:

- <50 m³ = Size 1
- 50–<500 m³ = Size 2
- 500–<3,000 m³ = Size 3
- 3,000–<25,000 m³ = Size 4
- 25,000–<200,000 m³ = Size 5

This convention is an analytical assumption introduced for this study and should not be interpreted as the official CAA definition of the size classes.

2.6 Classification method 2: Geometric interpolation of half sizes

Half sizes are commonly used operationally in Canada, but they are not formally defined in the CAA size scale. The 2024 OGRS states that half sizes may be used by experienced practitioners for avalanches considered midway between defined size classes (Canadian Avalanche Association, 2024)

Because the size scale is approximately logarithmic, a geometric mean was used to generate intermediate volume values:

$$Vhalf = \sqrt{(Vlower \times Vupper)} \quad (2)$$

This produced the following research-derived intermediate values:

Size	Typical deposit volume (m³)
1	50
1.5	158
2	500
2.5	1,225
3	3,000
3.5	8,660
4	25,000
4.5	70,711
5	200,000

Table 1: Avalanche size with typical deposit volume listed in the 2024 OGRS expanded to include half size avalanches.

These half-size volume values are not an established component of the CAA size scale. They represent a methodological convention developed for this analysis to permit comparison with the half-size observations present in the dataset.

2.7 Classification method 3: Whole-size thresholds based on lower limit of the size above

The third method treated the published typical deposit volumes as boundaries from the lower limit of the size above. Under this convention:

- <500 m³ = Size 1
- 500–<3,000 m³ = Size 2
- 3,000–<25,000 m³ = Size 3
- 25,000–<200,000 m³ = Size 4
- >200,000 m³ Size 5

2.8 Comparison with practitioner-assigned size

The size assigned by the practitioner in InfoEx was compared with the size derived from the calculated geometric volume proxy.

Three comparisons were made:

1. practitioner-assigned size versus whole-size volume classification;
2. practitioner-assigned size versus volume classification incorporating the geometric half-size thresholds; and
3. practitioner-assigned size versus an alternative classification convention in which the volume was assigned to the lower size class until the next published typical-volume value was reached.

The purpose of these comparisons was to determine whether the apparent difference between practitioner-assigned and calculated size was sensitive to the choice of numerical boundary.

3. RESULTS

3.1 Dataset

The operation reported 99 avalanches during the study period. Of these, 71 contained complete data for avalanche size, width, length and crown depth and were included in the quantitative analysis.

Of the 71 complete observations:

- 39 were assigned half sizes (1.5, 2.5 or 3.5); and
- 32 were assigned whole sizes.

The distribution of practitioner-assigned sizes was:

Avalanche Size	Number of reported avalanches
1	10
1.5	15
2	29
2.5	11
3	4
3.5	2
4	0
4.5	0
5	0
Total	**71**

Table 3: Practitioner reported avalanches reported by size

The majority of recorded avalanches were therefore assigned Sizes 1.5–2.5, with Size 2 being the most frequently reported classification.

3.2 Comparison of calculated and practitioner-assigned size

Using the whole-size volume thresholds, the 71 avalanches were classified as follows:

Avalanche Size	Practitioner reported values	Method 1: Number of Avalanches by method of calculated volume	Method 2: Number of Avalanches by method of calculated volume	Method 3: Number of Avalanches by method of calculated volume
1	10	4	4	21
1.5	15	-	4	-
2	29	17	13	25
2.5	11	-	14	-
3	4	25	11	21
3.5	2	-	12	-
4	0	21	9	2
4.5	0	-	1	-
5	0	4	3	2

Table 4: Practitioner reported values of avalanche size compared against 3 methods of calculating geometric volume proxy of avalanche size.

Overall, the calculated geometric volume proxy tended to produce larger size classifications than those assigned by practitioners regardless which method was used.

The greatest apparent discrepancy occurred around the transition between Sizes 2 and 3. The volume-based calculation also produced several Size 4 and Size 5 classifications despite no Size 4 or Size 5 avalanches being assigned by practitioners in the original dataset. With respect to the size 5 calculations, in each instance it was a size 3 or 3.5 avalanche that was recategorized by the calculations.

4. LIMITATIONS

Several limitations affect the interpretation of this analysis. First, the CAA typical deposit volumes are not defined as formal upper or lower boundaries for avalanche size classes. Consequently, different reasonable approaches to assigning size from volume produce substantially different results, particularly for Size 1 and Size 2 avalanches.

Second, the geometric volume calculation assumes a rectangular avalanche and uses recorded width, length and crown depth as proxies for volume. Avalanche geometry is rarely rectangular, and the definition of avalanche length is not consistently applied in practice. In addition, larger avalanches may entrain substantial snow beyond the initial release area.

Third, the accuracy of the calculated volume is limited by uncertainty in the underlying measurements. Crown depth is often measured directly, whereas length and width are frequently estimated from photographs, mapping tools or satellite imagery. These uncertainties are compounded when the measurements are multiplied.

Finally, half sizes are commonly used in operational practice but do not have a standardized numerical definition. The geometric interpolation used in this analysis is therefore a proposed methodological convention rather than an established component of the CAA avalanche size scale.

5. INTERPRETATION

The calculated geometric volume proxy was frequently associated with a larger avalanche size than the practitioner-assigned size, with discrepancies of approximately 0.5–2 size classes observed. Given the approximately logarithmic nature of the avalanche size scale, a difference of one size class represents a substantial difference in the physical magnitude of an avalanche, rather than a small incremental difference.

However, these results should be interpreted cautiously. The analysis demonstrates a discrepancy between practitioner-assigned size and a calculated volume proxy; it does not establish that practitioners systematically underestimate avalanche size. The calculated proxy has not been validated against measured avalanche deposit volume, mass, or destructive potential.

6. CONCLUSION

This analysis highlights an opportunity to improve consistency in avalanche-size reporting by making greater use of the quantitative information already collected by avalanche professionals. Currently avalanche professionals using the InfoEx report avalanche width, length and crown depth as well as practitioner assigned sizes yet these collected dimensions are not established ways of precisely identifying avalanche size.

The substantial differences observed between practitioner-assigned size and the calculated volume proxy suggest that further investigation is warranted. A rectangular prism is simple but perhaps not the best shape to calculate size. Standardized measurements of avalanche deposits, including volume, depth, density and potentially mass, could provide an empirical benchmark against which practitioner size estimates can be evaluated.

Such data could help assess interrater reliability, clarify the relationship between physical avalanche characteristics and the existing size scale, and determine whether systematic over- or underestimation of avalanche size occurs.

This study is intended as a proof of concept rather than a proposed replacement for professional avalanche-size assessment. Its primary finding is that routinely collected avalanche observations may provide an opportunity to develop a more quantitative and consistent approach to understanding avalanche size.

7. REFERENCES

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