Should the proposed scale focus on the risk-based interpretation of avalanche size (less specific to terrain features in the deposit)? Should interpretation guidance (e.g. footnotes) state whether or not the terrain features of a specific avalanche be considered? An example would be: Relatively harmless to a person, where no terrain traps or fall hazards exist.

Open-Ended Responses:

- Yes, I like the way the example is worded. I often teach "A size one avalanche can still kill or bury a person in a terrain trap, similar to drowning in a few inches of water if lying down"
- I like the example. Footnote stating whether or not terrain features are considered. I would need to see an example of risk-based interpretation of avalanche size to have an opinion.

- Yes, I think this will clarify classification.

- No interpretation guidance

- Yes

- No, too prescribed of a rating scheme will make it less effective for edge cases. It should be hazard-based and not risk-based, as the element at risk is not always humans.

- Yes, a focus on risk. Gullies/cliffs/glades do not change the size of the avalanche. Footnotes should accompany if there is potential for size 2 consequences (traps/falls/trauma) from a size <2 slide.

- I think the scale should be relative to the size and mass only, e.g you are expected to see only size 1, and people should make their own judgment call before crossing above a cliff. An small size one avalanche could be triggered in a path without anyone in it and it remains a sz 1, but then you put a person and they get push over a cliff and died and now it become a sz 2???. If the cliff wasn't there it would remain a sz 1 but if they died going over the cliff the size of the avalanche become a sz 2???? This makes no sense to me, the terrain is the main factor not the avalanche size in this. If someone tell me it was a sz 2 I will picture a much bigger avalanche..

- I support this reasoning. Adding footnotes helps with clarity.

- Scale should be focused on volume.

- I think size of avalanche and terrain feature should be separate categories. This would make standardization easier.

- I like the approach of avalanche size remaining independent from terrain features. I think specific footnotes could help people separate hazard and risk.

- It would seem to me that the consideration of terrain traps or fall hazards is inherent when considering avalanche size. In most basic avalanche courses I have taught we always emphasize that while a size 1 avalanche does not by definition state that it will

bury or kill a person, if there is a terrain trap or cliff feature that you may be pushed into or carried over, then even a small avalanche could be extremely hazardous. I think the defined size of an avalanche should be kept separate from the terrain and you manage the risk based on combining the two.

- Yes
- Yes, keep it risk based. I think that the whole scale should be "where no terrain traps or fall hazards exits". I would prefer to see the scale remain as simple as possible / am not sure this needs to be included
- No
- Yes
- No. I don't think this would be helpful. Any risk-based interpretation would add more personal subjectivity to the assessment (and there is already a lot of subjectivity now)
- Yes, I prefer the scale does not consider terrain features in the deposit. And yes, the footnote would help.
- Yes
- Footnotes - especially for recreational users as they can underestimate the severity of a size 1 or size 2. Putting emphasis that the destructive potential is correlated to terrain will hopefully prompt them to identify terrain traps more regularly.
- Re Table1, Perla 1980, size could depend on three or four variables.
- I like the example when using the scale to communicate risk. I feel the key word in the subjective description of a D1 is "relatively harmless"
- This should already be taught. I have always taught destructive potential.
- Yes, as the example above.
- No to both questions. In my view, the only way to generate consistency is to remove the subject fields of rating avalanches. Stick to easily measurable parameters. Length, width, depth etc.
- Terrain features should be considered.
- Yes in theory, though it may be hard to apply consistently. Once again, descriptive comments and preferably photos are much more illustrative than just a size classification alone.
- Perhaps differentiating scales according to purpose: 1) hazard assessment (less terrain specific); 2) risk management decision making (more terrain specific)

- Avalanche size can be less specific to terrain features if interpretation guidance is stated. It's probably the best way to go. When teaching we can separate terrain traps/fall hazards from avalanche sizing.

- Yes, the proposed destructive size scale of avalanches should be independent of terrain features. When reading avalanche observations, practitioners should immediately know the order of magnitude dimensions (length, mass) of an avalanche, based solely on the destructive size listed. This is a key feature for practitioners who often need to scan hundreds of avalanche observations in a short period of time, identifying those which are relevant to their own workflow at a glance.

- No

- Since destructive potential is not necessarily correlative to burial, injury, or morality, I think it should be standardized regardless of the terrain in any part of the path that might affect any of those outcomes. Burial is one kind of mechanism for injury in an avalanche but not the only one. So, yes, I like the given example with the footnote, but not sure it would work well to qualify when terrain traps or fall hazards do exist.

- Yes

Are there any scenarios from your experience where terrain features have influenced your size rating?

Open-Ended Responses

- Sometimes I feel the scale and size of the path influences size ratings of avalanche. For example a smaller ski hill might report a size 3 on a feature that goes larger than normal and full path while another bigger ski hill may look at the avalanche and see it as a 2 or 2.5 because they are often seeing avalanches of that size regularly on slopes not going full feature. It seems when there is an anomaly things seem to get bumped up the size scale.

- Forecasting for ice climbers, I frequently have terrain features influencing danger ratings. It doesn't typically influence size rating but requires warning in the text about terrain traps.

- Yes, a very small avalanche failed on a suncrust down about 20 cm resulting in a skier injury increased the avalanche rating from a size 1 to a size 2.

- Likely, though I try to just use the size of the avalanche.

- No

- Not to my knowledge -- I attempt to rate as I was taught, based on the most destructive area of the avalanche (e.g., confined track).

- We discuss those scenarios as "size 1 avalanches with size 2 consequences."

- Somewhat, when the debris get completely spread out thin on a wide planar slope (run out). As a result the destruction potential was really low, it could have not really push a person or do much damage.
- There are lots of places where a very small (size 1) avalanche that is able to move thru treed terrain may kill you by pushing you into a tree, or tree well, but was a relatively small mass of snow moving, and would be harmless if it wasn't in treed terrain.

- No.

- No

- While I try not to let terrain influence my size ratings, I know it happens. I can think of one avalanche where I had a close call and the debris piled deeply in a gulley and I called it a 2.5, while my coworkers who were not involved in the close call called it a 2.

- I would say we have a harder time estimating size of large avalanches especially from a distance as we don't see them as often and so often size 3 avalanche may actually be classified as 4s. Conversely when snow pours over cliff features etc. if can look much larger than it actually is if you are considering sheer volume of snow.

- Only in the respect that large features can produce more destructive avalanches. For example, a 20cm thick slab on a small slope may only result in a size 1 avalanche, but on a very large slope may result in perhaps a size 2.5.

- They almost always do. It requires practice, open discussion (when possible), and experience to avoid having this influence.

- Yes, I think the root of the problem is the definition for size 1 avalanches being harmless to humans. This is incorrect, all avalanches are a potential hazard to humans other than a 0.5. I think 1.5 is used commonly to indicate the avalanche won't have a big volume but can be potentially dangerous.

- they used to be part of my determination of size, but I have since moved to a more volume based estimation, and then add notes for specific human risk potential, ie terrain traps.

- initially I thought no. But I guess a terrain feature altering the runout and making a deposit look "larger" (=more volume) vs a thin, widespread deposit.

- Likely yes, but I try not to. I try to think about the mass and speed of the snow.

- No

- Yes, I personally size up when I see an avalanche with a deep deposit in a terrain trap. It is challenging to imagine the size of it without the terrain trap and how deep the debris would be.

- Re Table 1, Perla 1980, e.g. vertical descent is a "terrain" variable.
- Not consciously, though I've initially rated an avalanche one size larger until I was able to determine the amount of existing debris in the runout (from a recent, previous event).

- Plunging avalanches onto a road where a size 1 most certain has potential to bury/injure or kill a person and damage a vehicle. Therefore an avalanche with a mass of size 1 may have have size 2 or larger consequences based on the terrain and location within the terrain. In my opinion however it is still a size 1 avalanche as the mass can be measured or estimated whereas consequences maybe more ambiguous or difficult to quantify.

- No. I separate terrain from snow. Terrain doesn't change. Snow does. Destructive force should be the only factors. What increases force? F=ma .. increase mass (density of snow or amount of snow) increase acceleration (speed of the snow movement).

- Not that I can think of, but it has probably happened..

- No. I tend to focus on the quantifiable elements of the avalanche. length, width, volume, mass, density etc.

- Yes

- I find avalanches that pile up in a terrain trap, such as a highway, appear much bigger than those that fan out in the runout with a thinner deposit covering a wider area. In a sense, the same volume of debris can look much more impressive if piled meters deep on a highway.

- Datasets from research from SFU may suggest that activity type influences perceptions of vulnerability to size ratings.

- Yes, mostly where terrain traps increase deposit depth.

- Yes. My initial reaction to avalanches in terrain with consequence (including simple gladed forest) is often more visceral than my initial reaction to an avalanche of similar dimensions on a planar alpine slope. I personally lean heavily on the dimensional guidance for avalanche size, and this often helps me recalibrate my gut reaction into a quantifiably defensible size.

- Yes of course.

- Yes, if typical path length is considered a terrain feature. Also, path geometry/configuration may have influenced size rating.

- Yes, with a glide slab avalanche where the road cut through previous debris made the deposit deeper.

In many regions, backcountry users share observations, including avalanche observations, with other backcountry users and public forecasters (e.g. Mountain Information Network in Canada) Should greater destructive potential due to terrain features that are typical of the regional mountain environment (e.g. gullies and chokes) be considered when sharing observed avalanche size?

Open-Ended Response

- No, but pictures are worth a thousand words.

- Again, I'm having a hard time visualizing what this would look like. I would need to see an example to have an opinion on it.

- Yes

- I don’t think so.

- No

- Perhaps in comments but not in size ratings.

- Terrain features that may increase destructive potential should be considered and discussed, but it should not change the size of the slide.

- Yes, because funneling the debris will increase its size at a certain spot and destruction potential.

- I think this is a difficult thing to manage. At the 'intermediate' level of recreational avalanche education we spend a LOT of time talking about terrain and my experience teaching AST2 tells me that many people leave *just* starting to integrate that into their thinking, so then asking them to make or interpret specific terrain modifiers is likely beyond most recreationalists.

- No. Scale should be focused on volume.
- No, terrain should be shared separately.
- Maybe we could encourage MIN users to rate size independently of terrain features, but have a check box or something stating that risk is or would be higher due to terrain features.
- No. I think the potential avalanche size should remain consistent with the current definition and we should continue to educate people to consider the hazard within the terrain they are travelling in such that a size 1 avalanche could bury or kill someone in an area where there are lots of gullies/chokes/cliffs etc.
- I think it should be relative to destructive potential without the influence of terrain traps or specific features, unless we are talking about large features that typically result in larger, more destructive avalanches.
- No, avalanches should be classed regardless of the terrain.
- No
- No
- No. But the terrain features could be noted as separate variable for observations. But they should not be linked to interpreting avalanche size.
- No, including more contextual information in ratings can hamper consistent communication. I prefer the rating focus on the amount/speed of snow. The reader can then apply that amount of snow to whatever terrain feature is relevant to them. Any contextual terrain characteristics are better placed as a comment rather than in the rating.
- No
- Yes, would be good to have checkboxes when reporting an avalanche so we are able to gain more information from observations.
- "gully" is not a size, but is important to know.
- Observed size estimates should focus on the volume of the avalanche, independent of the local terrain features. BC users should be aware of their local terrain and how it applies to certain sized avalanches.

- It is important to emphasise that smaller avalanches may have greater consequences as a result or terrain features or lower snow cover but the size should not change based on regional differences.

- Terrain features are important because they play a role in consequence. A size 1 can have more destructive potential when more destructive terrain. Backcountry users will not recognize this and put themselves at risk. A baby can drown in a bathtub.. does this mean the water was dangerous? No.. but it was to the baby. Just like small avalanches are not dangerous with trained backcountry user... they know how to manage risk.

- No

- No

- Yes

- I think the MIN report submissions should strive for a good description of size and consequence, with photos where possible. This will carry much more weight for the AvCAN forecasters than a size rating from a backcountry user with no supporting information.

- If a hazard assessment specific and risk management decision-making specific scale were to be developed, I would suggest that public forecasts, MIN reports, and AST courses educate users to adopt the risk management/terrain-based scale.

- I think we can start trending towards everyone including terrain trap comments, and indicating when the seriousness of a particular avalanche is increased, when reporting.

- No. In fact, the MIN reporting system should be improved to give contributors adequate tools to assist in their avalanche size determination. A web-based calculator with variables of the avalanche slab width, length, depth, and hand hardness for example, would help produce more accurate avalanche sizes in MIN reports. A prominent note should explain that terrain-specific consequences are to be excluded from the size determination.

- No

- Ideally no.

- If the greater destructive potential was added into supporting comments, the size should be consistent.

Since avalanche mass or volume is more consistent over terrain than destructive potential, should the proposed scale indicate weighting (or state a preference for using) mass or volume more than the other descriptors (columns) like destructive potential or avalanche length?

Open-Ended Responses

- I think mass and volume are harder to estimate and picture, especially consistently across practitioners and recreationalists alike. Using the destructive potential I think makes people more consistent in reporting sizes. Example, picturing a cabin in the path of the avalanche- would this get destroyed? I think is more accurate for people to guess at then is that 400m or 600m run length? I would bet that if you asked 100 avalanche technicians to ski 30m down hill most of them would all stop at different spots. In my experience ski patrolling and guiding some ones "20m across" is different the the next persons. Its rare that we actually pull a tape measure out and calibrate our estimates. Additionally if it is a close call and like a surprising ski cut and it gets called in right away I think it often gets reported larger then if you see a small avalanche on a slope that has released 12 hrs ago. The scare or surprise factor can also make people estimate larger.

- Yes. Mass or Volume is more consistent. The issue is how to get a accurate mass or volume. It is relatively easy if you have access to the deposit or can get an idea from the area drawn on google earth. But is difficult when estimating avalanche D size from a distance-especially if you can't see the deposit.

- I think it should be considered but weighted lower in influence of size than destructive potential. Consider a 50 cm deep failure 1 Km wide running for 10 m. Huge but small.

- Yes

- YES

- Perhaps. Mass is inherently difficult to assess with unknown densities. Volume can be difficult if the underlying terrain is unknown. Practitioners/Professionals will need time and practice to improve estimation, particularly when only a subset of the path can be observed.

- Yes, I think mass is more objective and consistent in determining avalanche size.

- I think mass and volume should remain the main criteria with the suggested destruction potential.

- I support this reasoning. Length is not a great indicator; I have seen LD slides run for 100's of meters.

- Scale should be focused on volume.

- Yes

- I think we should emphasize using volume/mass. The problem is that it is so hard to visualize deposit volume/mass. Maybe the typical length for each size category could have a range of lengths that overlap between categories to help give guidance but encourage users not to rely too heavily on length as a metric.
- I think it is quite difficult for practitioners to estimate mass of volume of avalanches. I prefer the idea of looking at avalanche length, crown width and depth etc. to help estimate size of avalanche.

- I think that would be very difficult and misleading for non-professionals, and somewhat difficult and time-consuming to be accurate for professional. So no.

- Yes! Keep destructive potential too. Avalanche/run length is almost useless and should be eliminated.

- Yes

- Yes

- Personally, I tried comparing deposition volume with truck loads that would be needed to move the deposit. I found this helpful as a guidance (especially moving between size 2,3 and 4).

- I suppose that could help, but not sure how. It would be nice to communicate the weight of columns in our definitions because I think this causes a fair bit of inconsistency. A classic example is people getting caught up with the snowpack part of the avalanche problems rather than weighting the risk treatment part of the definition. So I'm not sure how you can communicate weights in a rating definition?

- Yes

- I think this would work well for professionals, but it would be extremely challenging for recreational users to guess the appropriate size when reporting on the MIN.

- Same answer as to 1.

- I opt for the mass/volume approach, with an emphasis on volume.

- Yes. Mass or volume can be easily measured or estimated to give a definitive size classification independent of terrain. Whereas both destructive potential and avalanche length can be heavily influenced by terrain and are therefore less consistent.

- Confusing question.

- Yes

- Yes

- No

- Volume is a good one and,as stated, a good calibrator for the size allocated to an avalanche. That said, while it is relatively straightforward to estimate the volume of the slab that released, it is really hard to account for entrainment at a glance, without decent measurements on the ground. Entrainment can be a big determinant of the overall mass, volume and destructive potential, so it is important to account for. I think this is why we default to a "guestimation" of destructive potential.

- I don't feel qualified to weigh in on this one. (Ha! Get it?)

- Calculating mass or volume is based on facts, destructive potential is more open to interpretation. But training on how to calculate mass and volume needs to take place before we can go this route. And even then observer's biases will come into play. Destructive potential still needs to be part of the scale, calculating volume will help determine destructive potential though.

- Perhaps, but I would question whether mass is indeed a better predictor of destructive potential than for example, run length. I personally find that the divergence of avalanche mass and run length for a given destructive size is more pronounced at larger avalanche sizes. In such cases, I perceive that the avalanche run length is a significant indicator of an avalanche's destructive potential. For example, if one were to compare two avalanches of similar mass, with one travelling twice the distance, I imagine an element at risk being more severely damaged by travelling the longer distance (or being impacted by the avalanche which had the energy to travel the longer distance). I do not think that many practitioners have the ability to judge at a glance whether an avalanche could destroy a pickup truck or a rail car, and hence, it is my view that these destructive descriptors should be for reference only and not for use in determining the destructive size of an avalanche, unless such an element at risk is indeed damaged in that avalanche.

- Yes. Let’s go with volume as a quantitive measurement.

- I think yes for consistency, but no for more practical reasons.

- Yes, with focus on volume.

Should the proposed scale use deposit mass or deposit volume or both? Deposit mass is more related to destructive potential than deposit volume. However, deposit volume is easier to visualize and does not require that deposit density be estimated. (The scale developed by the European Avalanche Warning Services (EAWS), which is based on the Canadian Scale, uses volume. The US avalanche encyclopedia now includes a visual aid for estimating volume.)

Open-Ended Response

- I think both would be helpful as well as still keeping in destructive potential.
- Volume is easier to visualize and requires less math and estimation of deposit density.
- I think that if mass and volume are easily integrated into the classification, that would be best. Otherwise just deposit volume.
- Volume
- Volume prioritized, but include mass also (ie wet avalanches)
- I believe mass is difficult to assess for most practitioners. We attempt to teach it in ITP L2 but I feel uptake is low. Volume is likely better. Mass is still not necessarily related to destructive potential, depending on path setup. Velocity is just as important, which is not part of our estimation (although included in overall impact pressure).
- Yes, both mass and volume.
- no opinion
- This might be one of the places where the practice of professionals differs slightly from the practice of recreationalists. Pros should be able to use mass, where recreationalists are likely going to need to work in volume. The Euro idea of talking about runout vs. slope steepness might be helpful to incorporate.
- Scale should be focused on volume.
- Both
- I think mass is more important than volume, but mass is so difficult to estimate in the field, which is where ratings are usually made. I think its so difficult to visualize density in the field, that people probably think of these two terms interchangeably. So I'm not sure

using one or the other would make a huge difference. The only main issue I can think of is that a wet deposit of smaller volume could be the same size as a dry deposit of larger volume. I don't have a great solution or idea for this, but its worth thinking about.

- See previous questions response. Based on above I would suggest volume is easiest for a practitioner to estimate.

- Perhaps incorporating deposit mass, which might be reasonably measure with aids like Google Earth. I feel measuring mass would be too time consuming and difficult.
- Keep it simple. Are there some easy metrics (like estimated moisture content) that could be used to calculate mass? If not, maybe just stick with volume.

- deposit volume

- deposit volume

- Volume

- Don't have a strong opinion here. I suppose visual training aids could help me calibrate and consider volume in my assessments more than I do currently.

- use both mass and volume

- Volume

- mass is hard to estimate.

- Again, I opt for volume. Mass influence the destructive potential, but so does speed (dry v. wet avalanches).

- Density can be estimated from hand hardness to calculate mass and thus differentiate hard slab or wind slab from fresh storm slab.

- F=ma. If the volume is large the Mass is large. If the density is high the mass is high. If both are high then the mass is very high. Stick with Force equation to determine destructive potential.

- Include a visual aid and find a common definition with EAWS.

- I think mass is the more accurate way to measure an avalanche, however if volume is easier for everyone the community will generate more consistency therefore that would be the more reliable option.

- Volume

- As a practitioner, I am often using thought experiments to assess destruction potential and determine risk recommendations.

- I think it's good to have both mass and volume in the table, but ultimately volume is much more practical for standard observations as its easier to roughly calculate with some measurements on Google Earth.

- Same as above.

- Volume

- I find the calculation of avalanche mass to be sufficiently simple that it should continue to be used. A simple spreadsheet or other calculator can be used to estimate the avalanche mass based on the density of the snowpack layers involved in the avalanche (or approximated through hand hardness of those layers).

- Volume not mass for deposits

- Maybe both.

- I like both systems. Volume is easier to visualize.

Should the proposed scale be primarily for use by avalanche practitioners and professionals? Should the proposed scale offer guidance on how people who have not seen many large avalanches in motion (e.g. backcountry recreationists, foresters) rate avalanche size? Should these users focus more on mass or volume?

Open-Ended Response

- I think the scale should be the same across the board, not different. Size is and will always be an estimation that gets better with experience. The more guidance the better through use of photos and videos and examples. I have found teaching beginners the easiest way is to picture the thing at risk - trees, person, train car in the path.

- Might need to test a new way to rate avalanche size with volume with some focus groups of laypeople and see which is more accurate.

- It should (and will likely) be used primarily by practitioners and professionals. The scale should definitely offer guidance (for consistency). The scale should focus more on mass, but include volume.

- Used by all. Guidance should be available.

- Same. Focus on Volume
- Any scale should be applicable to any person, recreating or working. Having different scales will increase confusion and uncertainty. Volume over mass, particularly since density is always an estimation anyways and is otherwise dependent on volume.

- Practitioners and professionals already have divided opinions on size ratings. I think focusing on having professionals all speaking the same language is most important.

- Consider both.

- Can we build more or less the same scale, and pros access it from the mass end and recreationalists access it from the volume end?

- All users should focus on volume.

- Primarily practitioners and professionals. It should be simple to understand and clear.

- I think the same scale should be used for practitioners and recreationists in order to facilitate communication and information sharing. Perhaps there could by two different sets of qualifying statements for each group. The one for recreationists could provide extra guidance for people who don't often see large avalanches.

- I think volume is still easier for people with less training to use to help calculate size. If some kind of rough dimensions (such as those proposed by McClung) reflective average crown depth, width and avalanche length be included as guidance for estimating avalanche size that would be beneficial instead of just providing volume estimates.

- I question how often professional would take the time to calculate mass or volume. Consider a Xh mission with 20 shots and more than 15 results - I certainly would not spend the time to calculate mass or volume for the results. I believe that public submissions (MIN reports) are typically weighted less than professional observations due to inconsistencies in recreationalists' observations.

- I think we need one scale that can be used for both recreational and professional users. It may not be necessary to communicate anything other than destructive potential with recreational users. I would suspect that trying to get recreational users to use math would result in way less reporting. Recreational users need to be encouraged to include photos.

- Should be used by all.

- Introduce & modify scale thru professional avenues - then bring into recreational venues. Proposed scale can be supported with educational tactics to help with rating (and separately describing the destructive potential) - don't build the guidance into the scale itself. Users to focus on volume estimation. In addition, focus on volume when estimating size may (hopefully) help users estimate potential avalanche size when reviewing terrain features & depths of weak/trigger layers. It can be quite surprising how small a slope will produce a size 2 avalanche (volume definition) with a weak layer down 30cm.

- Yes, guidance helps (comparing to other "measurable" things like trucks). Volume.

- I wonder about also improving the public definitions. For example, in Canada our problems use "small", "large" and "very large", then we use numbers in the avalanche summary as well as the option to report numeric sizes in the MIN. Perhaps there's value in creating a combined professional and public scale, or at least guidance on how to apply the professional scale to non-professionals.

- For use by both, offer guidance. For these user focused more on volume.

- I think offering footnotes for recreationalists would be helpful for them to understand the importance of terrain identification.

- Mass is hard to estimate.

- The scale is far more useful and accurate for professional use. Less experienced users should use a volume and runout estimate.

- Practitioners should focus on mass given their higher level of expertise and ability to differentiate between avalanche types whereas other users with less experience should focus on volume using guidance on how to estimate this.

- A professional with lots of experience will always report more accurately. Make sure you give more weight to professional observations and treat non-professional observations with a degree of error.

- Primarily focus on practitioners and professionals. Should not include guidance towards the general public.

- Yes. Yes. Volume.

- No, yes, volume.

- I think we all have to use the same scale, but maybe, similar to the ATES scale, we have a public model and a more detailed technical model that share common language and sizes.

- I recommend that empirical evidence from a study of how lay people most commonly understand avalanche size (mass vs. volume vs. vulnerability) inform this decision. It's a great research question!

- One scale for all. The more guidance the better. Volume.

- The propose scale should be primarily for use by avalanche professionals. Sufficient tools (smartphone calculator app, for example) should be made available for lay people to estimate an avalanche's size, such that they "get close" to the correct size when reporting.

- Professionals needs to focus more on volume. Recreational users should remain focused on the D scale.

- Scale should be for pros primarily. Recreational public already gets a layperson's version from forecast centers.

- The scale should be the same throughout all user groups. Following the Euro model with photos and videos would be helpful. Many practitioners and professionals have not seen large avalanches in motion.

Should visualizing potential damage to a person (on foot), a passenger car, a wood frame house, a rail car, a few trees, forests, or a village be part of the proposed scale? Should visualizing the potential burial of a person, a passenger car, or a rail car be part of the proposed scale?

Open-Ended Response

- Both and yes for visualizing.

- I think it is an intuitive way to describe most avalanches. It is just the terrain trap part which is tricky.

- Yes, I think the visualisation is helpful.

- Burial not damage.

- Yes, but right now this has more "weight" than something that is measurable like volume and mass. This should be reversed. "Can it bury a car without a terrain trap?"

- If destructive potential is the main classifier then yes, visualizations are good. But the wording of them should be modified to include various types of elements at risk for each scale.
- I think the visualization of destructive potential is helpful. Potential burial may also be helpful.

- Yes, as a second visualization aid.

- I think for recreationalists this is very helpful, especially when I'm teaching AST2. What kind of thing would this avalanche wreck is a helpful tool for folks who don't think about things like mass and density.

- Visualization can stay but the primary focus should be volume.

- It should be separately from the size.

- I think so because I remember that being really helpful for me when I was new to the industry. It would be good to somehow de-emphasize these metrics though. I don't have great suggestions for this because I know this is the column that people's eyes are drawn to when they look at the chart of avalanche size.

- Yes, I would say this is applicable, especially for recreational users. This is where it could get tricky with a terrain trap and the definition of burry or damage - but the volume of the avalanche shouldn't change.

- Good question. Perhaps a mix of both? I feel I typically visualize the potential for burial of a person for smaller avalanches, and visualize the potential damage to cars, houses, etc. with larger avalanches.

- Yes, and yes.

- Potential damage.

- No - this would be part of a descriptor, or foot note, addition to the scale.

- It can be part of it as a help to differentiate the size classes but I would not consider it on the object side (=keep hazard and risk separated as long as possible). Mainly because risk is (qualitatively and quantitatively) subjective to the object.

- It's been a helpful way for me to rate sizes in the field, but not sure if it's the best way. Don't know...

- Yes, to both.

- Yes, I think it is helpful to have some sort of visualization of destructive potential.

- Yes, one of the important variable.
- The visualization of potential damage is a tricky one. Could bury an person or car is easier to visualize (volume-based) than "damage a wood-framed house". How many wood-framed houses have you seen get smoked by an avalanche? Likely not enough to maintain a good scale of reference.

- It can sometimes be difficult to estimate the extent and depth of debris deposits especially from a distance or for larger avalanches. Preference should be given to estimating the area and depth of the slab that released. This can be added by using measuring tools such as google earth to give a more consistent size rating.

- The size of an avalanche is important because it will determine the potential for loss. Using examples if a good way to teach. Keep them in. But emphasize the potential for loss as the real reason.

- Yes and yes.

- No. No.

- Yes, yes.

- I think the existing graduation of destructive potential is good.

- Same as above.

- Yes.

- Ha! I mentioned this above, but I perceive that most practitioners are quite lowsy at estimating whether a pile of snow could destroy a given element at risk. It is my stance that these descriptors should be for reference only, unless the specific elements at risk are indeed involved in the avalanche (for example, an avalanche destroys a swath of mature timber of known area)

- No

- I think it is good to use them as examples to visualize, but not to define the scale.

- Keeping the scale to easily pictured items is useful. in North America, a village is not as common as Europe. Cars, rail and passenger are more easily visualized.

The current definition of size 5 is "Largest snow avalanches known; could destroy a forest of 40 ha." For avalanches that could destroy about 40 ha and have the typical mass and run length of size 5 avalanches, some practitioners classify the avalanches as Size 4 or 4.5 because the avalanche was not one of the "largest snow avalanches known". Should this phrase be deleted from the proposed scale?

Open-Ended Response

- I like this phrase. A size 5 should not be thrown down lightly. I think it's rare we actually see these sized avalanches in Canada on our mountain scale. My parting words would be just a reminder that its always an estimate and no matter what the wording or classification there will always be disagreements and people classifying things different based on experience, I think this should be accepted but also its good to give more examples and guidance to help get people closer to the same page. It's snow science but its also snow art in my opinion and not everything fits perfectly into a box when dealing with nature as much as we would like it to.

- It should be deleted.

- Yes, the statement is too subjective.

- Yes.

- Yes. Delete. Also, consider adding a size 6, as there are avalanches of a magnitude larger than the current definition of mass and volume for a size 5. 5.

- YES!

- Yes.

- No, it is representative of the most extreme events in the world.

- The US encyclopedia visual aids did a good job of putting scope/relative size to size 5. Largest known is hard to quantify, and implies you need experience beyond your current avalanche region (i.e. someone working in the US NE versus someone working in the Himalaya). This might be a bit like the river rapid classification system where they said the top end rapids were "unsurviveable" and then some pros pushing the envelope when and paddled them, needing the creation of "class 6 rapids".

- Either or. Once again volume based is key!

- Yes

- I think it could be helpful to remove this phrase if we want people to actually use size 5. I like the phrase, because it sounds cool and imposing, but I do think it also sounds a bit like a historical relic.

- Yes that is a vague statement - is this referring to climax avalanche for that path, or largest avalanche ever. It's definitely a very subjective phrase and could be removed.

- Probably. Might be best to keep it to wording on destructive potential, run length, etc.

- Yes. If it's a size 5 it should be reported as such. If we can't have size 5s in Canada because of the terrain, we should either eliminate this from the scale, or change the scale so that we can have size 5s. As it stands it is under utilized and not helping us as practitioners as a result.

- Yes

- Yes - scale needs to be open ended & reflect the exponential nature of the volume. The presentation by B Jamieson (CAA Penticton meetings in early 2000's, I think) of the large avalanches observed off Tumbledown (?) at Selkirk Mountain Experience are an excellent example that the current scale is limiting in capturing the magnitude of potential avalanche events. Add that & the rapid changes in environmental (weather) events & we need tools that can be adaptable to describe the unexpected. The black swans are here - if the reviewers know those concepts.

- Yes. Because "largest avalanche known" is subjective. With the goal to push any standardized towards objectivity as much as possible. I personally found that just this phrase biased many avalanches to be downgraded to the 4.5 but in fact there are size 5 avalanches when looking at the objective criterias (volume, length, etc.).

- Yes, I agree this is a deterrent to using size 5.

- Yes

- Yes, I feel size 5's are very often underreported due to this statement.

- Re Perla 1980, table 1, size 5 is extreme, order of magnitude bigger than 4.

- Delete the phrase and stick to volume.

- Yes delete. Offers little in the way of guidance, too subjective.

- Yes. I would also like to mention that MANY professionals call small avalanches size 0.5 . Maybe there should be a yearly reminder that there is no such thing as a 0.5 and the scale starts with 1 and goes to 5. You can use a 1.5 or 2.5 when you are communicating the it was a large 1 or a larger than normal 2.. this gives a buffer for the observer to account for any error in destructive potential measurement.

- Yes

- Yes. I think the definitions of the avalanche sizes need to be specific and quantifiable numbers. Past that there could be examples that help visualize the debris, but I do not think these visualizations should be part of the formal definition.

- Yes

- Yes.

- Yes please.

- "Largest known" does seem too subjective for the purpose of the scale.

- Yes

- No, that descriptor is accurate. This is a cultural problem. Reporting of these large avalanches should be encouraged, provided that sufficient backup information/calculations are available to verify the size reported.

- Delete the phrase.

- I’m fine with that.

- Yes

Directly following the CAA Spring conference presentation there was some valuable back and forth through email. These conversations have been captured here for your reference. Names and Operations redacted.

On May 1, 2023,

Hi,

Thanks for the heads up. I just got to Penticton late tonight so this is some bedtime 🌙 reading.

I like my avalanche size to be based on the avalanche, not the terrain. We often take measurements to check our size estimates, so the mass numbers are a useful reference.

I would like to see a different definition for size 1 because we all know a size 1 can be harmful in the wrong terrain. But I still think it's a size 1 😁.

If size ratings varied with terrain, wouldn't it be anarchy out there as that would further complicate the estimating process?

On May 3, 2023:

I haven't had a chance to talk to [redacted] or Brendan yet about the feedback they received. However, most of the feedback I received was consistent with Lisa's point of view. Remove/revise/clarify the terrain specific parts of the size classification and clarify the role of potential consequences. This puts more weight on mass or volume as an indicator of size.

On May 4, 2023:

Yes thanks gang for the conversation starter! I've had a ton of good discussions since and my impression is that there is definitely an appetite to change the descriptors for size 1 and 2, but nothing further. I support this change, where the consequences of terrain traps are described better in the size 1 definition but it does not change the size rating of the slide. As well, the descriptor for size 2 gets revised, likely shortened.
One important theme that came up a few times is that having the word "kill" in the size 2 descriptor might be causing a lot of the biases mentioned. Worksafe and employers may be latching onto that word and (logically enough) declaring size 2's are unacceptable no matter what, because it could kill you. Size 1's can kill you too as we pointed out, so it might help our industry to report size 2s more accurately if they weren't defined by likelihood of a fatality.

Something like
Size 1: Typically harmless to people where no terrain traps are involved (with a definition of terrain trap added somewhere)
Size 2: Large enough to bury several people

Just spitballing but the more I talk about it with various people the more I like it.
Thoughts?
This could become the issw talk potentially and i think it would be a great panel discussion with some international voices at the table...

May 5, 2023

We're there any discussions on the Size 5 description? Perhaps the "largest known avalanches" evokes some under sizing bias?

May 5, 2023

Hi,

Our recent presentation was about Size 1 and 2 avalanches.
However, in the discussion following Mark Grist's fine presentation, Johann Slam mentioned the "largest snow avalanches known" was not helpful.
Also, in my presentations (with co-presenters) on av size in the last 2 years, the same point has come up repeatedly.

May 8, 2023:

Hi everyone,

Thanks for an interesting and thought provoking talk last week. I am glad to see some modifications to avalanche size descriptors are on the table for a future OGRS revision. I appreciate you including me and hope these comments are constructive.

- I was confused why a proposal was on the table to make the determination of the size of an avalanche based upon terrain traps (exposure) and skill of the element-at-risk (vulnerability). This would only further confuse estimating the size of an avalanche by introducing more variables unrelated to the snow. This would be a dramatic break from trying to size an avalanche based on the size of the avalanche (independent of terrain or people). I support Lisa's position, which was sure well delivered by Tyler 😊 nice job!

- Avalanche size has been defined in 2010 as language for the danger scale (see table 2 below) and the European Avalanche Warning Services have a slightly different version. They have a

"medium" avalanche, and we did not want to have a medium. https://www.avalanches.org/standards/avalanche-size/

Table 2. Danger Scale terms for avalanche size and their corresponding destructive size.	
Danger Scale Term	Avalanche Size Range
Small	< Size D2
Large	Size D2 to D3
Very Large	> Size D3

- I fully agree that size 1 should be changed and it could be as simple as ***"relatively harmless to people, except in terrain traps".*** Simple and with an anchor to what has been used for decades. I would not want to throw away too much of what has worked for us to date.

- I also think the word "kill" is fine as part of size 2 - because it's true and I find it helpful when evaluating the size. I personally don't like changes intended to pacify a regulator and avoid the ugly truth, and a size 2 can bury you and kill you. I find this part useful.

- I agree with whoever said (Scott?) that getting rid of "largest avalanche known" could be useful for a size 5. This probably biases all of us to not use this size, because I assume an avalanche down the SW face of Mt Everest must be bigger than anything I will observe. If that first sentence was gone from size 5, the rest would still work fine. We might even see a few more recorded.

- Although the typical mass measurements are simple orders of magnitude, I like them. I often measure an avalanche size that is in dispute and this helps me to decide. Any way these could be tightened up? I wonder if there is any research that gives more weight to these size ranges?

This was the kind of presentation that everyone loves at those meetings – relevant, practical and addressing something that everyone has a stake in. I think everyone enjoyed it! Thanks for putting the topic on the table and including me for feedback.

May 9, 2023:

Good discussion points.

Some of my thoughts:

Risk based interpretation of avalanche size

As one participant stated "There has been a generational change in the interpretation of avalanche size."

The original paper on avalanche size states: "The system used in Canada is based upon estimated potential destructive effects." In the early 1980s at the Fernie ski area, if an avalanche could kill a person, it was a size 2 or larger.

Risk concepts and risk-based assessments were introduced sometime after 1990, maybe after 1995? The adoption of risk concepts into avalanche practice has been gaining ground. Section 10.3 of the Planning methods book shows – convincingly, I think – that the magnitude is an **essential** part of the scenario. I hope changes to the Size classification will reflect modern risk concepts. In the early 1980s, I didn't know what a risk scenario was.

Terrain

Terrain is mentioned in the size classification, but change may be helpful. In OGRS, the second sentence under the table says: "The destructive potential of avalanches is a function of their mass, speed and density as well as the **length and cross section of the path**." e.g. gullies, confined terrain.

I have not taught an ITP course for 6 years, but I recall statements about terrain like "big start zones can produce bigger avalanches" and "Slopes over 45 degrees tend to produce smaller avalanches than slopes under 40 degrees".

In the discussion to the 1980 paper by McClung and Schaerer, McClung says "What you have to do is visualize if you can the point on the path where the greatest damage would occur; that is, at terminal velocity. It is just not the mass of the deposit. You have to look at the avalanche path, the runout--whether it is wet or dry, whether the path is **confined or unconfined**--and any destructive effects you can see, which are rare."

In the full room discussion after our 2023 presentation, Dave McClung stated "Avalanche size depends on dynamics" which depends on terrain. I will ask Ethan Greene why they changed the name of the scale to destructive force classification, which clearly depends on dynamics.

The recent US avalanche encyclopedia states "Avalanche sizes vary depending on snowpack conditions and terrain."

One of the more interesting comments about terrain came from a few participants Tyler talked to. They feel terrain in the start zones and track (including chokes, confined slopes) affects avalanche size but not terrain in the runout. (Tyler, I hope I have that correct?)

I see terrain as a large challenge for a risk-based avalanche size classification.

Escape skill

Apologies for not being clear. I did not intend this to be part of a proposal, but rather a bias that we should recognize. I think we should always visualize a person on foot. However, I recognize that changes to the destructive potential column may obviate this point.

Ability of observers

In his forestry book, Peter Weir used mass to estimate size. I assume this was because many readers of his book (e.g. foresters) would have limited ability to estimate the greatest damage that could occur in the track. Nowadays, the same

goes for MIN users. Mass or volume can be observed with some consistency, but not potential damage in the track. See the volume column in https://avalanche.org/avalanche-encyclopedia/#destructive-force-d-scale
**
Egads, what have we bitten off! Help!

May 9, 2023

Thanks,

Good points on the risk-basis. Are you aware of good definition of magnitude?

I note we did not include a definition of this in TASARM and I am having some trouble getting some clarity on this. There seems to be some mixing of terms here that all factor into this: size, destructive potential, mass, volume, dynamics, magnitude, intensity and probably more.

If **magnitude** is an essential part of the scenario, then having a clear understanding of what magnitude means will be helpful for this discussion.

It could be that I'm the only one who doesn't quite grasp this part clearly….

Try out this one and see if it resonates:

Jackson, L. E. (2016). Frequency and Magnitude of Events. In Encyclopedia of Natural Hazards (pp. 359–363). Springer Netherlands. https://doi.org/10.1007/978-1-4020-4399-4_147

May 10, 2023

Hi

"related to energy of the event" works for me.

In chapter 1 of the Planning Methods book (Jamieson and Statham), it says:
Depending on the situation, the relevant variable for avalanche magnitude can be either avalanche impact pressure, avalanche runout or avalanche size (e.g. destructive potential).
This is repeated in the Glossary. Impact pressure, runout and destructive potential are all related to the energy of the avalanche.

For most operational work, size works very well. For planning projects, the relevant magnitude variable can be size, impact pressure or runout. (There may be some

situations where flow depth is part of magnitude along with impact pressure. Jakob used velocity and flow height as the magnitude variable for debris flows.) Magnitude is the variable that determines vulnerability. In some situations, magnitude (e.g. runout) can also affect exposure.

Risk based planning projects require an assessment of vulnerability. Vulnerability (for each element of risk) is determined by magnitude of each scenario. This is why I refer to magnitude as an essential part of the scenario. I find the general definition of scenarios hard to grasp. I wish we had included examples.

Most hazard assessments are for a single scenario, e.g. what if a size 3 reaches the tower or road? In hazard assessments, we rarely talk about scenario because there is only one magnitude being considered.

I find the examples in Section 10.3 of the planning methods book helpful for understanding scenarios and magnitude. (FYI, Chapter 10 is by far the most re-written chapter of the Planning Methods book. Dave Gauthier sent my drafts back to me several times (it seemed like many times) with extensive red ink. He re-wrote some sections for compatibility with risk analysis for geohazards.)

Does this help?

All:

I heard back from Ethan Greene. He does not recall why they switched from destructive potential to destructive force. He is interested in the size scale in OGRS 2024 and would like to see a consistent scale in North America - if the SWAG committee likes the Canadian Scale.

May 10, 2023:

Thanks, that helps is consistent with what I thought magnitude meant. I wanted to be sure that it could be represented in various ways depending on the context and scenario.

I sure hope my geeking out here is relevant to this group, since I am a late invitee. Feel free to punt me off if not but I think it all relates to these questions of how we use avalanche size.

Here is one of the more difficult concepts to explain from the Conceptual Model, and it relates to how forecasters and guides use avalanche size. In CMAH risk model, consequence is broken into two parts: 1)

the destructive potential of the avalanche, which is part of the hazard assessment, and 2) the vulnerability of the element-at-risk, which is part of the risk assessment.

This is because in the model, hazard is separated from risk by way of exposure - if nothing is exposed, then nothing is at risk. When nothing specific is at risk, that allows us to assess backcountry hazard in a more general way (no risk scenario). Think 3/2/2 in CMH Revelstoke, for example, a broad rating with nothing at risk (yet) and scenarios based upon a problem type each with a location, likelihood and size. In this CMAH method, magnitude is represented by the destructive potential of the avalanche problem type, independent of anything at risk.

Then we introduce elements-at-risk, and now we have the complete scenario you describe as used for planning, except in this case the element moves. This makes for many different and always changing scenarios based upon the changing exposure of the element (in space/time) and their vulnerability to the hazard. This vulnerability represents the element's susceptibility to the hazard (i.e.: escape skills, PPE, ski ability, etc.) and changes alongside the changing exposure. When the element moves above a cliff, the low hazard (think size 1) is now a high risk. This is because the exposure and vulnerability has changed and put the person in a high risk situation. If they then decide to use a rope (for example), they become less vulnerable and their risk goes down.

This is why I think avalanche sizing should remain independent of any specific element-at-risk, because that enables us to make backcountry avalanche hazard assessments. A small avalanche is not high hazard, but it can make for a high risk situation depending on the exposure and vulnerability of the person.

May 10, 2023

Hi

I agree with: *This is why I think avalanche sizing should remain independent of any specific element-at-risk, because that enables us to make backcountry avalanche hazard assessments. A small avalanche is not high hazard, but it can make for a high risk situation depending on the exposure and vulnerability of the person.*

However, does visualizing the hypothetical damage done to a hypothetical person or car or rail car help us assign a size rating? I think so but there is some challenging communication to media, lawyers, managers, insurers, public ahead, e.g. when a person is killed by a size 1 in a terrain trap. IMO, the submission for a revised scale should clarify these cases up front. Lisa's "where there are no terrain traps" is an excellent example. More of this is required.

May 11, 2023

Hello All:

Great conversation, I just returned from my holiday opened my computer and saw the great back and forth. I feel like I now have a better idea of magnitude.

[redacted] you were correct in your previous email "They feel terrain in the start zones and track (including chokes, confined slopes) affects avalanche size but not terrain in the runout." This was a common sentiment which I found interesting. I feel people could more easily visualize debris accelerating through a choke increasing destructive potential but struggled to visualize the mass piled up and crushing things as destructive potential as well. I also noted that these were people who disagreed with my sales pitch for terrain effects and poor escape skill being considered within the destructive potential to help reduce the effects of bias on our size judgment.

I have read through the questions and will ruminate over them this week. I agree, I struggled a little with the terrain specific and not specific size rating questions and had to read them a couple of times. The other thing I did notice is that maybe we need to add to the pre-amble that the focus of the original observation was inconsistency in sizing between practitioners (and other observers as well) and that this work hopes to solve some of this by removing some of the notable biases and creating better visual and mental keys. For me looking at the original question helps to provide context and allows me to think about the weaknesses in the current system and how it affects my ability to judge size when answering the questions. But that might just be me.

I am in agreeance with [redacted] on not throwing away too much of what has come before. I feel that opening the descriptor for size 1 to reflect all the potential outcomes with this size of avalanche would be beneficial in removing inconsistency. Some folks may not like this as the size 1 may now be harmful, and unacceptable in some circumstances. I think the same would hold true for removing "Largest snow avalanches known" from size 5. When I read that I feel like it is something I would read in a headline of a newspaper or magazine. Eye catching but a poor visual of the actual event.

One last thing, could we have both mass and volume in the descriptors? Is this too much? Mass staying as is but adding volume descriptors to help with visualization. [redacted] your examples of these sorts of descriptors at EVSAW I thought were great. The idea of an apartment filled with a metre of debris resonated with me and my inability to visualize volume and relate it to size was laid plain during my incident this winter. I couldn't figure out how many small cars (my normal visual) were in my debris. Just some thoughts I had while reviewing the questions.

May 11, 2023

I think I qualify as one of those people who can easily visualize that debris accelerating through a choke will increase destructive potential, but I also disagreed with your sales pitch on terrain effects and escape skills adding to the destructive potential.

You got me 😜.

So here's two scenario's that I cannot resolve:

1. A relatively small avalanche (size 1) gets funneled through a tight gully making it more destructive. At that tight spot, it could break a few trees. Or maybe it could bury someone in a small gully. So we call call it a size 2 even though there is not much mass.

2. Another small avalanche runs down a smooth, planar slope that doesn't choke. So it remains a size 1. Except that a climber is just topping out and the small avalanche knocks them off their feet and they fall over a cliff below. They're dead. Following the logic above, is this now supposed to be a size 2? But the avalanche was small. Or, if that climber is anchored and the avalanche washes past with no bad effects, is it still a size 1 then?

Are these terrain effects? Or what are the differences between these two scenarios?

This is where I am having trouble coming to terms with terrain effects. I worry a lot about size 1 avalanches as a climber, but I've never thought it made the avalanche any larger.

Can anyone identify what I am missing about these scenarios and the terrain effects? What is the difference?

May 12, 2023

Hello All,

I think the survey questions look good and will provide some excellent feedback. I made a few notes let me know what you think. My one concern is that this may open more cans of worms. (both exciting and overwhelming) I think for me the solution and largest challenge is the acceptance that a size 1 is a larger hazard then we give it credit for. When I look at less than or equal to 10 tonnes written on paper it feels less hazardous then when I see it in real life. The volume is likely to be in excess of 20 cubic metres and depending on density could be much higher than this. Once exposed I see this as real risk. So as a solution do we decrease the size 1 to something that is truly relatively harmless no matter what, edge of a cliff? between two houses? Is this less than a tonne? Less than 1 m in length? Or do we accept that size 1's are a larger hazard then we give them credit for. Not all size 1's are just sluffs. Some are wind slabs. Some are wet slabs. Both of which are hard to manage even on skis. There for not relatively harmless.

[redacted], I think both scenarios are size 1 which could end up being reported as size 2's because the effects of the avalanche in that specific terrain (terrain effect) especially if you believe that the description in the Canadian Snow Avalanche Size-Classification System and Typical Factors is more important than mass and length. Which I know has and does happen and since there is no guidance on the weight of these categories I feel like they are not wrong, conversely those who believe the other way that mass and length are the critical factors making

both avalanches size 1 aren't wrong either. Here in lies the opportunity for discrepancy in sizing.

[redacted] would "kill a person on foot" include snowshoers, sledders (both tobogganers and snowmobilers), and Nordic skiers? What about children on skis? I like the use of "unlikely to bury a person" we could add injure or kill to this to cover all possibilities. It could happen, but only in rare and specific circumstances.

Every time I feel like I have a better understanding of the issues here the more questions I have. Like if size 1's are relatively harmless in comparison to size 2's but they are relatively harmful in comparison no avalanches at all how do you weigh this when estimating size? Was relatively harmless meant to be a comparison to the other avalanche sizes? I feel like that was the original intention but somehow, I'm not using the description in that way. Any way those are my thoughts for now.

May 13, 2023:

[redacted] et al.

A few opinions:

Your point about reducing the mass or volume of size 1s is excellent and would make a very good question.

The Europeans and Americans now include photos for each size. I think we should include photos in our proposed scale.

The current classification should - somehow - be handy to participants of the discussion group. Maybe a link. I propose we somehow include photos for each size, especially with your point about Size 1s.

I agree with overwhelming and wonder if there could be subforums in the discussion group so participants could contribute to 1-2 questions and not feel the need to deal with all questions. Or perhaps we could recommend that participants comment on 1-2 questions. Or perhaps the questions should be much simpler.

"Relatively harmless to a person **on foot"** was intended set a consistent visualization that would hopefully reduce the escape skill bias that I believe some skilled skiers, mountain sledders and their operations have. Just a drafty suggestion. "on foot" or whatever could be in the proposed descriptor or a footnote, although I worry that there can be too many footnotes.

Email comments from [redacted]

Hi [redacted]! Hi to all!

Very nice to hear from you and thanks a lot for your always detailed answer.

Great job you are doing in continuing the open discussion on the avalanche size classification consistency. I've read the ISSW abstract. I understand the first case (which we already discussed) on size 1 avalanches which reach localized burial terrain traps. The second case on the involved person/people skills to escape from the avalanche, I am not sure to have understood well, but think it is quite logical to stablish that when rating avalanche size, we don't have to do it according to the occurred consequences, if not the potential consequences. The people skills can differ greatly among users, and this is a feature out of the avalanche characteristics itself.

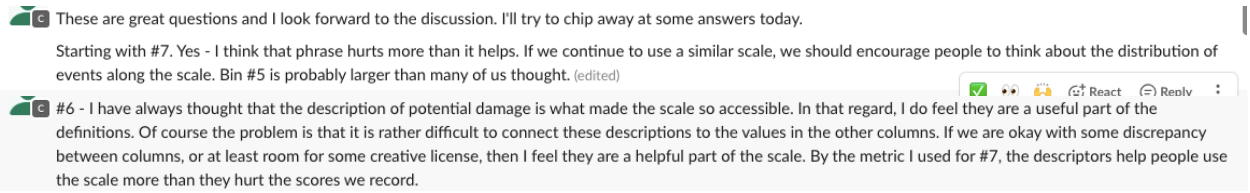
In addition and I imagine that you discuss that within the paper, is to talk about trauma type terrain traps in the avalanche path and/or deposit. Should we consider or not when rating? This is an important point.

The possible guideline to solve that should be what we have already discussed: "imagine the avalanche mass/volume falling down an open slope, without any terrain traps (burial and trauma) and imagine the person being involved at the highest destructive position of the avalanche.

There is another detail which I don't if we have been discussing. It is the avalanche morphometrics. I mean, the same mass and volume, in a square avalanche or a more wide than long avalanche or more long that wide avalanche, the destructive potential bellow the fall of this snow mass/volume is different. And this is an inherent feature of the avalanche, not the terrain.

Well, these are my immediate thoughts.

SLACK Comments on the Survey questions:



Comments and pictures from [redacted]

Some of these items overlap, so I'll start with first principles:· I'd like to make the case for deposit mass (on a **logarithmic**, **open-ended** scale) as the gold standard for determining avalanche size. This is my answer to question #3.That said, (and now addressing question #4) volume *is* easier to visualize and calculate, so keep the excellent &

practical estimation aids referring to: apartments, houses, hockey rinks and football fields. See Note 13 below.NOTES:

1. Mass is objective, quantifiable, and as [redacted] mentioned, more related to destructive potential than volume. With evolving technologies like photogrammetry, LiDAR, SAR (satellite), I imagine we'll have remote, automated volume (and mass) calculations of avalanche deposits within 10-15 years, maybe sooner. That serves us well in the professional domain, but as noted, what about recreationists….?
2. That's where other descriptors/guidelines come in: Make use of photos like the EAWS scale does (because, after all, we are visual animals) and then let's write better descriptions for destructive potential (for example, size 2 should get rid of 'bury' and keep 'injure or kill a person'). I prefer the focus on potential damage vs. potential burial. This speaks to questions #5 and #6
3. Speaking of other descriptors or guidelines… would it be useful to take a page from ATES and have a *public communication model* in addition to a *technical model* if we go whole hog with a revised avalanche size scale?
4. We're used to logarithmic scales… think Richter scale for earthquakes.
5. An open-ended scale will create the mental space for size 5, or size 6 avalanches, and help us stop under-calling avalanche sizes. I'd say most practitioners currently have a mental block on size 5's, and it mostly has to do with the phrase 'largest snow avalanches known' … speaking to question #7, and we absolutely have to get rid of it! Auf Wiedersehn!
6. I was so happy when [redacted] mentioned "5.9" over coffee at the spring meetings: The Yosemite Decimal System (YDS) Class 5 started as a closed scale, and we're now, what…?... 24 grades beyond 5.9 now!!! I know that's a linear as opposed to a logarithmic scale but the concept remains: Why limit ourselves to closed scales, especially when considering time frames longer than a practitioner's career?
7. Back to question #7 and 'largest snow avalanches known'… in some practitioner's minds, I imagine it goes something like, "Well, if the whole Rupal face of Nanga Parbat went in a climax avalanche… it might be a size 5". We may find that scenario – if it ever happened - is a size 7 (or larger).
8. Employing the logarithmic mass scale, I would argue there have been documented:

Size 5.5 avalanches: At Bear Pass (E. Strohn [35.5] in 2001 was 5.3 to 8.0 x 10 exp 8 kg and Gunner [40.4] in 2011 was 4.7 to 7.1 x 10 exp 8 kg). Data taken from Table 3 in Bruce's 2014 Geohazards paper, and using 400 to 600 kg/m3 deposit density.

Size 6 avalanches: (defined as > 10 exp 6 tonnes or 10 exp 9 kg). Tumbledown in 2011 (1.3 – 2.0 x 10 exp 9 kg) , and at least two in the Taconnaz path (see fig. 4 in Naaim et. al 2010… the masses range from 1.8 to 2.7 x 10 exp 9 kg, using 400 to 600 kg/m3 deposit density.

9. Question #5: Again, I think providing example photos and qualifying comments will help people dial in their sizing. For example, Size 5 and larger avalanches could have a descriptor like: **When seen from the air, heavy machinery is dwarfed by the**

deposit. The first two attached photos illustrate this concept. Thanks to Johann for the first photo (E. Strohn, I believe). The second photo is Jack Mac from last year.

10. More descriptors for size 5 and larger could be:
Significant amounts of snow in the deposit will remain when the next winter arrives. Typical dense flow deposit depths range between 10-40m, especially where there is a confining feature in the runout zone like a river or narrow valley bottom. Again, emerging technologies will help us determine deposit depths (and volumes) with greater accuracy. From our spring presentation: Over 31 days in Sept-Oct (7-8 months after the avalanche) approx. 45,000 m3 of avalanche debris (mostly snow) was removed. Typical volume ranges for a size 4 avalanche are 20,000 to 35,000 m3 (from Table 2 in Bruce's 2014 Geohazards paper). Just last week (May 23rd) I observed there is still snow 3m+ deep, on the far side of the Illecillewaet River below path 47.8 (Jack MacDonald)…see third attached image. It's now 16 months after that size 5 avalanche! (For the record: We didn't have an avalanche over the shed this past winter, let alone across the river.)

11. In a perfect world, all descriptors / guidelines will align perfectly for each size. See the tight cluster of data points for size 3 in fig. 5 from Bruce's 2014 Geohazards paper (fourth attachment, circled in light blue). This speaks to high accuracy AND precision, which is exactly what we want. (https://en.wikipedia.org/wiki/Accuracy_and_precision)

12. Speaking of high precision, I think we need to tweak our destructive potential descriptions and volume numbers to better align with the corresponding logarithmic mass scale… if we do decide that mass is the primary factor. 13. Minor detail: It would be good to specify *which* type of football field, as a Canadian football field is 52% larger than an American football field, for example.

American football field = 5,351 m2
International football (aka 'Soccer') pitch = 7,144 m2
Canadian football field = 8,152 m2 (edited)

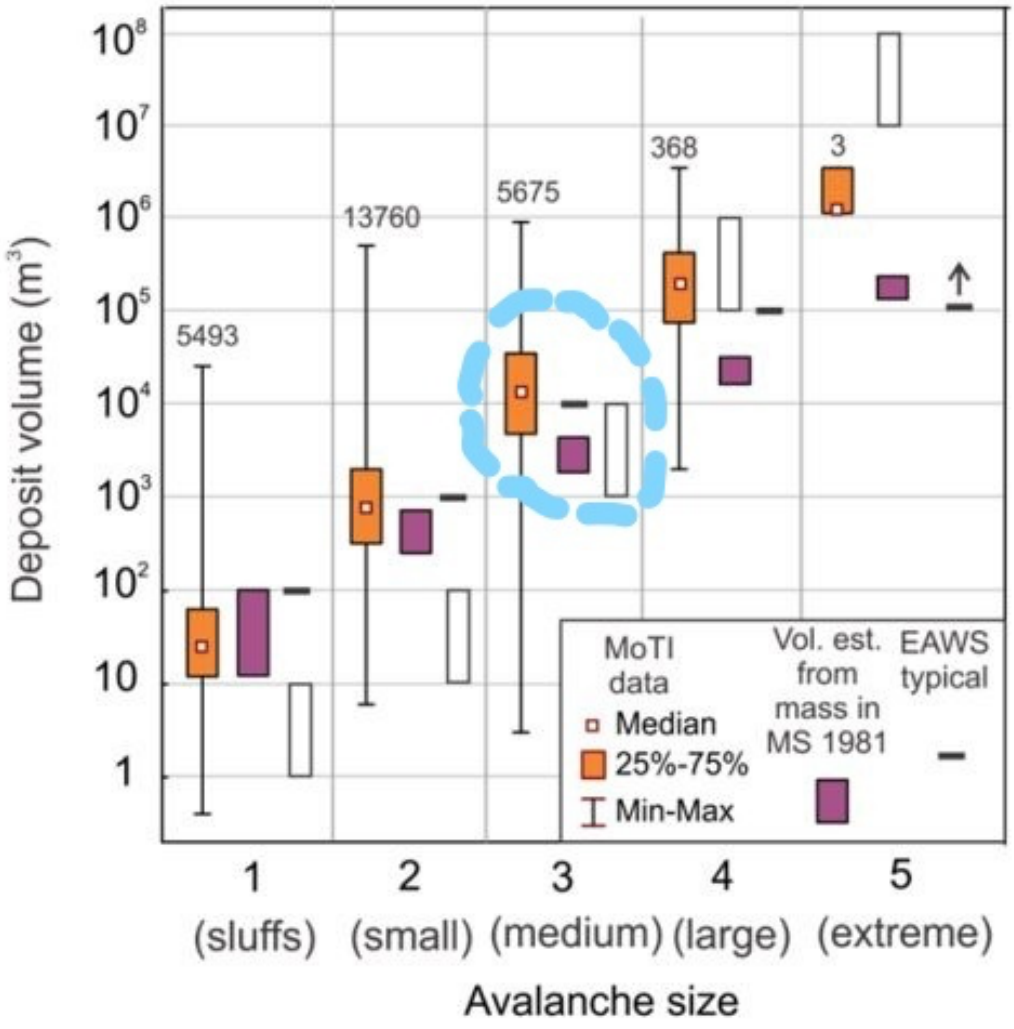


Figure 5. Avalanche volume by size. Orange boxes with whiskers are from BC MoTI data. Half-size avalanches not shown. Numbers above the whiskers indicate the number of avalanches. Purple boxes are the volume ranges estimated from typical mass (MS 1981) and the ranges of typical deposit density in Table 2. Black bars are typical volume from European Avalanche Warning Services (Moner et al. 2013). White boxes are ranges from Perla (1980); labels in parentheses below numerical sizes are from Perla (1980).