PHOTOGENIC AVALANCHES: WHAT MAKES AN OBSERVER PHOTO USEFUL FOR ESTIMATING AVALANCHE SIZE?

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ABSTRACT: People entering the backcountry rely on avalanche forecasts for up-to-date knowledge about the avalanche hazard. In return, backcountry travelers support avalanche forecast centers by sharing their snowpack and avalanche observations on public observation platforms. These submissions often include photos in addition to written information. Avalanche centers in southcentral Alaska get hundreds of photos of avalanches seasonally from the public and professionals recreating in the forecast area. Avalanche forecasters then use these photos to assess avalanches they have not seen firsthand, though these photos are not always as informative as they could be.

Our main objective is to identify the photo characteristics that best support avalanche size estimation, so that destructive potential can be estimated accurately, consistently, and reliably from observational photos. As a proof of concept, we distributed an online survey to 13 professional public avalanche forecasters in Alaska and asked them to estimate the size of ten avalanches using public observation photos. In addition to size, forecasters also described the photo qualities that helped with sizing, their confidence in their assessment, and their prior knowledge of the pictured avalanche or slope.

In this pilot phase, we found that reference objects played a major role in supporting sizing consistency between professionals, and that photo angle/completeness – including a clear view of the crown, track, and debris – supported more confidence and consistency in size assessments. In the coming season we plan to collect additional data to build on these preliminary findings, to identify best practices for observers when photographing avalanches. This guidance could be utilized by avalanche forecast centers to educate public observers on how to take higher-quality photos and thereby improve forecasters' ability to estimate avalanche size from images.

KEYWORDS: Avalanche forecasting, avalanche size, observations, photos

1. INTRODUCTION

Professional avalanche forecasters can only see so much terrain first-hand on any given day in the field. As a result, public backcountry avalanche forecasting operations rely on community observations to get a clearer picture of avalanche conditions across a forecast zone. During the 2023-2024 season across the United States, a total of 24,000 photos were included as a part of 4,600 public observations submitted through the shared avalanche forecasting platform that 20 avalanche centers across the country utilized that season (USDA Forest Service National Avalanche Center, 2024). These photos provided awareness of avalanches that otherwise may not have been known to forecasters, across a combined 104,000 square kilometers of advisory areas.

Understanding the potential size of avalanches in a region is a critical component of estimating hazard in a public avalanche forecast. In the United States, avalanches are assigned sizes on a 1-5 scale in two ways, including the relative-to-path (R) scale which sizes a specific avalanche against the size that a specific path is capable of producing, and the destructive (D) scale which quantifies avalanche size by the harm an avalanche may cause to people, vehicles, or even large forests (American Avalanche Association, 2022). The difference between a D1 avalanche (relatively harmless to a person) and a D2 avalanche (could kill or injure a person) is large and getting the size estimate correct is an important component of the conceptual model of avalanche hazard in shaping an avalanche forecast (Statham et al., 2017).

While photos of avalanches have the potential to provide information, not all avalanche photos are equal in the utility they provide to an avalanche forecast center. Photos in full light or flat light can hide definition, making it hard to see the crown and other defining features of the avalanche. The cropping or angle of a photograph may omit critical information about an avalanche event. Photos taken up close

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with a wide-angle lens can warp the edges of the photo, potentially making avalanches appear wider and unintentionally misleading the observer (Banks et al., 2023). In the field, observations taken from a distance - where an avalanche is viewed in the context of surrounding terrain – can lead observers to underestimate size (Carson et al., 2023), and this tendency may apply in photographs as well. There are more factors, including reference objects that can provide a sense of scale, which may affect size estimation. Finally, avalanche forecasters do not always agree on size estimates when presented with the same photograph. A recent study involving 170 avalanche professionals found 74% agreement on estimated avalanche size when they evaluated a series of photographs from Switzerland (Hafner et al., 2023).

To better understand the specific elements of avalanche photos that may improve accuracy, consistency, and confidence when sizing avalanches from photographs, we developed a proof-of-concept survey to help shape our future avalanche sizing research. Our goal is to eventually provide guidance to public observers on best practices they should consider when photographing avalanches in the field. In addition, we aim to improve awareness of the limitations and variations that should be expected when forecasters size avalanches from photographs. Understanding limitations may help forecast centers decide whether to invest more time and resources in emerging avalanche sizing tools. One example is monoplotting, where a single photo is put on terrain utilizing a GIS platform, giving a forecaster the ability to accurately measure the width and height of the crown as well as the runout (Bozzini et al., 2013). These tools may increase accuracy, but such systems require an investment of forecaster time and software. If accuracy is already satisfactory using current photographic sizing techniques, an avalanche center may choose to forgo such an investment of time and effort, saving energy for other elements of developing a public avalanche forecast.

2. METHODS

We distributed a proof-of-concept online survey to Alaskan public backcountry avalanche forecasters to better understand how they size avalanches from photos. Our specific interest was to learn what elements of observational photos help forecasters evaluate avalanche destructive size accurately and consistently. The survey was delivered using Google Forms and was approved by the Alaska Pacific University Institutional Review Board.

2.1 Photos

Photos of ten avalanches for this project were collected from Alaskan forecasters and the public observation platform on the Chugach National Forest Avalanche Center website. Photos represented D-scale sizes ranging from 1-3. We manipulated one avalanche photo and presented it twice, first in photo 3a after editing out distinct reference objects (snowmachines and people), and second in photo 3b, unedited with people and snowmachines present near the crown and debris (Figure 1).

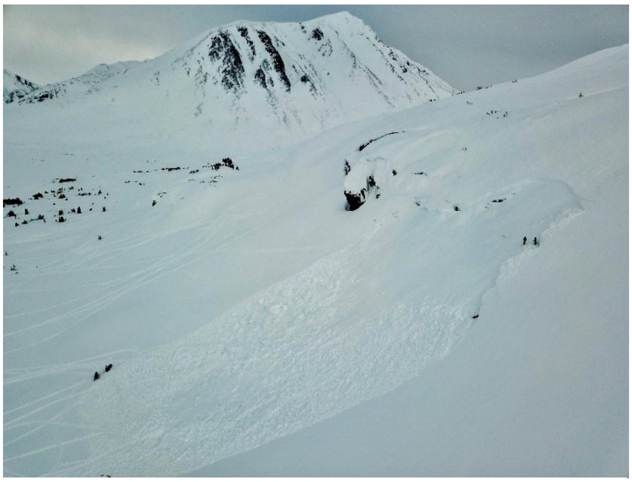
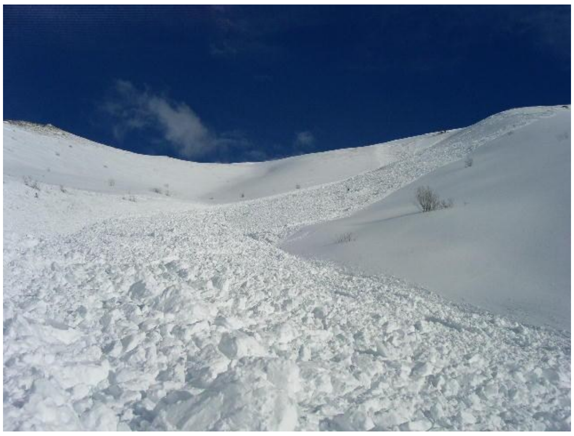


Figure 1: An example survey photo – photo 3b – which included distinct reference objects.

Six avalanche photos had distinct reference objects, including people, snowmachines, and/or trees of obvious size near the avalanche crown or debris pile. The other five avalanche photos had no distinct reference objects, but contained less obvious reference objects for scale, such as ski/snowmachine tracks, rocks, or a climbing rope in the foreground, along with vegetation of unclear size (Figure 2).



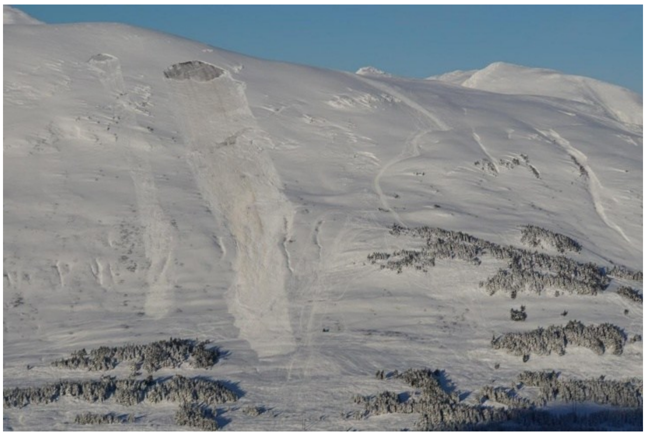


Figure 2: Additional survey photos. Photo 5 (left) features an incomplete view of the avalanche, due to image cropping/angle. Photo 2 (right) was the photo that featured highest forecaster confidence.

Lighting in all photographs included good contrast, while the angle and location of the observer to each avalanche varied. Photographer positions included above the crown, along the side of the track, or down below the toe of the debris. In some images, the photographer was standing on the debris pile, while in others the photographer was kilometers away from the avalanche with a telephoto lens. In six photos, the entirety of the crown, path, and debris pile could be viewed in the image. The remaining five photos obscured a small or large portion of the avalanche, due to observer angle and/or cropping.

2.2 Survey questions

For each of the photos, we asked four questions. The fundamental question asked the forecaster to estimate the destructive size of the avalanche using the photo. The second question asked the forecaster to write in their own words which photo qualities helped them determine the size. The responses explained what the survey participants were looking for or missing in the pictures for the sizing task. The follow-up questions asked how confident forecasters were in their sizing estimation on a 1-5 scale, and about prior knowledge of the avalanche/slope. Although confidence can stem from factors like professional experience or training, we asked about prior knowledge of the specific avalanche/terrain, as this factor may have influenced their assessment and confidence.

2.3 Data analysis

The data was imported into a spreadsheet, cleaned and organized for the analysis, and we used an exploratory mixed methods approach in this pilot phase. We categorized each of our photos by elements they included, such as whether distinct reference objects were present in the image, and if the entirety of the avalanche could be viewed by the forecaster. We averaged forecasters' confidence in their assessment, creating a ranking of photographs that produced the most confidence versus the least confidence in our forecaster sample. D-size variation for each photo was noted by calculating the difference between the smallest and largest size estimate provided by forecasters. Finally, we reviewed written forecaster responses of helpful photo qualities, counting how many individual responses noted reference objects for scale, the photograph angle, and/or slope familiarity as some example themes. The small sample size is insufficient for statistical analysis, but we did a descriptive summary of the data set, which is included in Table 1.

2.4 Respondents

We invited professional public avalanche forecasters from Alaskan regional avalanche forecasting centers to participate in our survey via targeted recruitment email. Most of our 13 respondents worked with the Chugach National Forest Avalanche Center (5) and the Hatcher Pass Avalanche Center (6), but we also had one participant from the Valdez Avalanche Center and one from the Coastal Alaska Avalanche Center in Juneau. The participants had professional experience in all the different snow climates. The participants were mostly seasoned in their profession; five forecasters have worked more than 10 seasons, four have worked 6-10 seasons, three forecasters worked 1-5 seasons, and one forecaster worked for less than 1 season.

3. RESULTS

Overall, the 13 respondents answered four questions for each of the 11 photographs, resulting in 143 unique responses to each question type. Our analysis centered on the open response “useful photo qualities” question, and we compared themes from those answers against specific photo qualities, forecaster confidence, and the range of size estimates provided for each avalanche. The summary of main results is in Table 1.

3.1 Distinct reference object

Our main finding is the importance of a reference object when deciding the size of an avalanche from a photo. 57% (81/143) of individual survey responses noted using something in the frame to better understand the scale of specific parts of an avalanche, including the crown depth/width, path length, and/or the extent of debris.

In the six photos that included a distinct reference object, 77% (60/78) of survey responses mentioned a reference object as helping them pick out an avalanche size. In the five photos that didn’t include a distinct reference object, respondents still attempted to use something for scale, with 32% of (21/65) responses noting the use of ski tracks, rocks, brush, or neighboring terrain as elements providing a sense of scale.

Forecasters produced more consistent size estimates for avalanches in photos that included distinct reference objects. The majority (4/6) of photos that included a distinct reference object had a D-scale size spread of 1, while the majority (4/5) of photos without a distinct reference object had a D-scale size spread of 1.5. This may indicate that reference objects of a distinct size in close proximity to an avalanche may help produce consistency among avalanche professionals.

Forecaster confidence was notably higher in size assessment when photos included a distinct reference object. Five of the six photos that featured a distinct reference object were ranked the highest for confidence in our 11 photos, while forecasters had the least confidence in four out of five photos that lacked distinct reference objects.

Finally, we compared differences in responses for the avalanche that was presented twice in the survey, first without people and snowmachines, and second with those distinct reference objects added back in. Six of the thirteen forecasters modified their size estimate after the distinct reference objects were added back in, and the range of D-size estimates was reduced from 1.5 to 1 with the inclusion of distinct reference objects. Average forecaster confidence increased slightly when people were present near the crown, though several forecasters lowered their personal confidence assessment when the people were added back in to the image.

3.2. Photographic angle/cropping

While the survey did not specifically ask respondents to highlight elements of the photographs that made sizing difficult, a handful of responses (12/143) noted that viewing the avalanche from the side, and/or photo cropping that left out crown width/depth, track length, or debris pile information added to the challenge of sizing an avalanche from a photo. Additionally, five responses noted how useful it was to see the whole avalanche, when the complete crown, track, and debris pile was included in the image. One forecaster noted that a lack of information due to photo angle increased uncertainty in their size estimation, and overall, the five photos that lacked the “complete picture” ranked in the bottom half of all photos presented for forecaster sizing confidence.

3.3. Familiarity

Avalanche forecasters had varying familiarity with avalanches and slopes in the survey, ranging from 12 out of 13 being familiar with a specific avalanche path in a photo, down to no one recognizing a slope in another photo. In instances where a forecaster indicated that they were familiar with the slope, they cited that familiarity as helpful in sizing the avalanche in the open response question about one third of the time (14/43). As this open-response question asked specifically about photo qualities that were useful in sizing the avalanche and not whether personal experience was useful, this result should be viewed with caution. That said, this suggests that forecasters often utilized their familiarity of a specific slope when later sizing avalanches on that slope from photographs.

3.4. Other photographic elements

A handful of responses noted how photos that clearly depicted an avalanche problem were useful when estimating avalanche size, with glide, storm slab, and loose snow avalanches receiving mentions a total of six times. Lighting was mentioned just twice, but generally each photograph had good contrast in the sample, leaving this photo quality untested in this proof-of-concept survey.

Table 1: Summary of survey photographs and forecaster responses, sorted by forecaster confidence from highest (most confident) to lowest

Photo #	*Survey Photo Details*		*Distinct Reference Objects*		*Destructive Size*		*Forecaster Confidence*	*Forecaster Familiarity*
	Avalanche Type	*View of Entire Avalanche?*	*In Photo?*	*Survey Mentions*	*Survey Estimates*	*Range D-Sizes*		
2	Glide	Yes	Yes	8/13	D2–3	1	1/11 (highest)	12/13
1	Slab	Yes	Yes	11/13	D1–2	1	2/11	2/13
3b	Slab	Yes	Yes	12/13	D2–3	1	Tie – 3/11	1/13
6	Slab	Yes	Yes	13/13	D1–3	2	Tie – 3/11	6/13
3a	Slab	Yes	No – Edited Out	9/13	D1–2.5	1.5	Tie – 5/11	1/13
7	Slab	Yes	Yes	8/13	D1.5–2.5	1	Tie – 5/11	10/13
8	Slab	No – Some debris cropped out	Yes	8/13	D1–2.5	1.5	7/11	1/13
9	Slab	No – Angle obscures view	*No*	2/13	D1–2	1	8/11	4/13
5	Slab	No – Angle obscures full crown, some debris cropped out	*No*	4/13	D2–3.5	1.5	9/11	2/13
10	Slab	No – Some debris cropped out	*No*	4/13	D1–2.5	1.5	10/11	4/13
4	Glide	No – Track obscured, no debris	*No*	2/13	D2–3.5	1.5	11/11 (lowest)	0/13

4. DISCUSSION

In our sample, forecasters often used reference objects to better understand the width/depth of a crown, the length of the track, and the extent of avalanche debris. In instances where a distinct object of a known size was present in the photos, forecaster confidence increased, and the spread in D-scale size estimates tended to shrink as well. When a distinct object was lacking, other objects - such as ski tracks, rocks, bushes, or neighboring terrain - were relied upon by forecasters in their size estimation. While the survey was not designed to capture forecaster frustrations, the absence of the complete picture - including the entirety of the crown, track, and debris pile - added uncertainty and tended to reduce forecaster confidence.

Consistency and confidence in avalanche size assessments are two things that avalanche operations may strive for in their operations, but it should be clear that this survey did not attempt to check forecaster photo assessments for field accuracy. Practitioners can better understand their own tendencies by judging the size of an avalanche from a distance and then checking that estimate at the site of an avalanche (Jamieson B., 2022). Techniques that use technology - such as monoplotting - or calculators that measure avalanche mass using snowpack inputs and slab/debris pile dimensions could be incorporated into future research on avalanche sizing based on photographs, so that an operation doesn't end up being confident and consistent in an incorrect size estimate.

Future research into sizing avalanches from photographs must also be tied in with broader research on avalanche sizing consistency among avalanche professionals. The lack of a standardized, step-by-step procedure for avalanche size estimation, along with a lack of universally understood definitions and descriptors of volume or path length, are two factors that may lead to inconsistencies among practitioners (Carson et al., 2023). Potential solutions like online training videos may help observers strengthen their destructive potential estimate processes, in the field and when viewing photographs alike (Jamieson et al., 2020).

This survey also just barely scratched the surface on how forecaster knowledge of a particular slope helps forecasters when they later size an avalanche from a photograph. As an example, one survey response from a forecaster with first-hand knowledge of a slope noted that the neighboring terrain in the photograph was deceptive, and his size estimation of that avalanche was on the larger end of forecaster estimations in the survey. Related, an additional limitation of this study is that photos and respondents were all from Alaska. Future research that includes a mixture of in and out-of-region photographs and forecasters may shed more light on how familiarity with a general region impacts sizing confidence, consistency, and accuracy.

Finally, the technique of editing out distinct reference objects generated useful evidence and warrants more use in future attempts to isolate variables in photographs. Combined with a more robust sample size and randomized photo order, future studies could better test individual variables with a stricter experimental design, providing clearer conclusions about specific photo elements.

5. CONCLUSION

This project gave insight into how our sample of professional forecasters approach photographs when sizing avalanches. Few firm conclusions can be drawn from this study, with the small sample size and the mixture of photo qualities being tested in each survey image. However, our initial results support future research into reference objects and capturing the 'entire picture' of an avalanche. As these are two elements of an avalanche photo that observers can often control in the field, forecast centers could provide recommendations about each photo element to public observers to increase observation quality, if future research confirms these initial findings. Future research should also review sizing accuracy, by utilizing technology like monoplotting (Bozzini et al., 2012), to ensure that consistency and confidence are not confused with accurately categorizing an avalanche by destructive potential.

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