

THE WISDOM OF CROWDS IN AVALANCHE FORECASTING

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ABSTRACT: Starting at least 28 years ago, the Utah Avalanche Center has strongly encouraged the public to submit avalanche observations and they have always been an important source of information to augment professional observations in the creation of the daily avalanche advisory. The arrival of Web 2.0 and especially social media, allowed for much more efficient, two-way communication, which has vastly increased the accuracy, geographic coverage and timeliness of avalanche hazard communication. Non-professional observations from volunteer observers and the public (crowdsourcing) now comprise the bulk of information used to create the Utah Avalanche Center advisory. Plus, new social mediums such as Twitter, Instagram and Facebook provide continuous, two-way communication between the public, forecasters and traditional media outlets throughout the day. This paper details how the Utah Avalanche Center, as well as other avalanche centers, utilize crowdsourcing and social media to dramatically improve the accuracy, geographic coverage and avalanche communication between all entities concerned with avalanche hazard.

KEYWORDS: 3-6 keywords (crowdsourcing, forecasting, public information, observations, social media).

1. INTRODUCTION

During the 2013-14 season alone, non-professionals submitted 930 detailed observations to the Utah Avalanche Center database via a web form, 90% of which included either photos, videos or detailed snow profiles. In addition, the public regularly notified us of critical, backcountry avalanche activity using Instagram, Twitter, Facebook, our own app, emails and the old-fashioned telephone call (see Fig. 3 for statistics). We regularly tweet important activity out to our network as soon as we hear about it, making real-time communication to the entire community, including television, radio and newspapers. We have found that observations submitted by non-professionals are not only very high quality and detailed, but the amount of useful information has eclipsed what we receive from professional avalanche organizations. Furthermore, by allowing the public to participate in the creation of the local avalanche bulletin, they feel included and take ownership in supporting the avalanche center not only with critical, backcountry observations, but financially.

2. BACKGROUND

2.1 *Observations*

At the Utah Avalanche Center, information comes from several sources:

- Professional avalanche entities such as ski areas, the Utah Department of Transportation and guiding services. These observations arrive via a web based, non-public, information exchange operated jointly by the National Weather Service and the Utah Avalanche Center. The information includes detailed weather data and a single text box in which they type a short summary of important avalanche information. We often talk with professional organizations by phone during active, or unusual, avalanche cycles. This information includes mostly avalanche control results.
- The Utah Avalanche Center staff, which perform fieldwork about 2-3 times per week. Seven forecasters operate throughout the state of Utah.
- Our volunteer observer program consists of about 30 regular, trusted observers who regularly recreate in backcountry avalanche terrain. We have an annual meeting with them and coach them on how to submit observations. Most are paid a

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nominal fee of \$10 USD per observation to pay for their time at the computer each evening submitting observations to our database via a web form.

- The general public submits observations to our database using a web form. Some use social media, email or leave information on a telephone answer machine, but the majority submits using the web form.

We post all observations (with the exception of avalanche control results from ski areas) on our website for public consumption. Here is a breakdown:

Observations submitted to the public UAC database during the 2013-14 season:

1290 total observations

28% from professional UAC forecasters

27% from our volunteer observer program

45% from the general public

Of 527-backcountry avalanche reported to this network, 90% included photos and 12% included videos.

Observations submitted to our professional information exchange:

We received 653 additional avalanche observations from our professional information exchange network. These are condensed summaries of avalanche activity typed into a text box. Occasionally, they will email photos of significant results.

2.2 *Social Media*

In addition, we utilize the following social media for two-way communication between forecasters and our customers:

Twitter: We use Twitter in two ways, 1) each day we tweet a short summary of the day's avalanche conditions with a link to the full advisory, and 2) we broadcast breaking news about avalanche activity throughout the day, many of them sent from the field with accompanying photos or videos. We also monitor replies and retweets utilizing Tweetdeck, plus, the feed from both Twitter and Instagram appears on the left margin in the forecaster's view on our webpage. In this way, the public can easily notify us of avalanche activity and send photos or videos. We utilize the hashtag #UTAVY and monitor other media that may use the hashtag. The media outlets regularly monitor our feed as well and use it as a source of breaking avalanche news and they sometimes use photos

of videos linked in our tweets. Our tweets are commonly retweeted by a wide variety of other users. The public can sign up for a phone text message of tweets to stay abreast of breaking news.

Instagram: The public sometimes uses Instagram as a way to quickly broadcast photos or video of avalanche activity along with a caption explaining what happened. As long as they include our hashtag in the caption, we can easily monitor the activity on our Tweetdeck or website, which displays both the Twitter feed and the Instagram feed on the left margin of the forecaster's view on our webpage. We often send an Instagram photo each time we issue an advisory with a link to the full advisory. This season, we tried to include a current photo of avalanche activity, or during slow times, we include stock photos.

Facebook: We use Facebook mainly for non-time-critical avalanche news. The Utah Avalanche Center is a partnership between the U.S. Forest Service and the nonprofit, Friends of Utah Avalanche Center. All forecasters work for the Forest Service and the nonprofit does fundraising, teaches avalanche classes and organizes promotional avalanche awareness and produces educational videos. The nonprofit usually updates the Facebook page and occasionally Forest Service forecasters will post pertinent avalanche news such as an important blog update. The public occasionally uses Facebook to report avalanche activity as well.

UAC App: We also have our own iPhone app (not yet available for Android). The public can use the app to display the advisory as well as critical weather and snowpack data. Plus, the public can use the app to take and share a photo of avalanche activity, which imprints latitude and longitude, slope steepness and aspect onto the photo, information potentially useful for search and rescue operations as well.

See fig. 1 for a breakdown of numbers.



Fig. 1: A breakdown of numbers from various media sources.

3. DISCUSSION

3.1 High-value observations

Avalanche hazard evaluation is a Bayesian process. In other words, we continually update our belief about the danger of the snowpack based on

incoming information. The forecaster does not use a numerical Bayesian model, but instead, we evaluate each piece of new information intuitively based on its significance and its probability of being true. We then update our preexisting belief about avalanche danger. Seeking significant, high-value information has also been called the bull's eye approach by Fredston and Fesler (2011) in which the information in the center of the bull's eye carries much more weight in swaying our belief than information on the outside of the bull's eye (fig. 2.).

The best sign of avalanches are avalanches. Nothing changes the mind of either a forecaster or the public with more authority than a good photo or video of a human triggered avalanche in backcountry terrain, especially if other photos and reports confirm it (Fig. 3). Both forecasters and the public receive great benefit from timely knowledge of recent avalanche activity, especially in visual form.

Bull's Eye Information

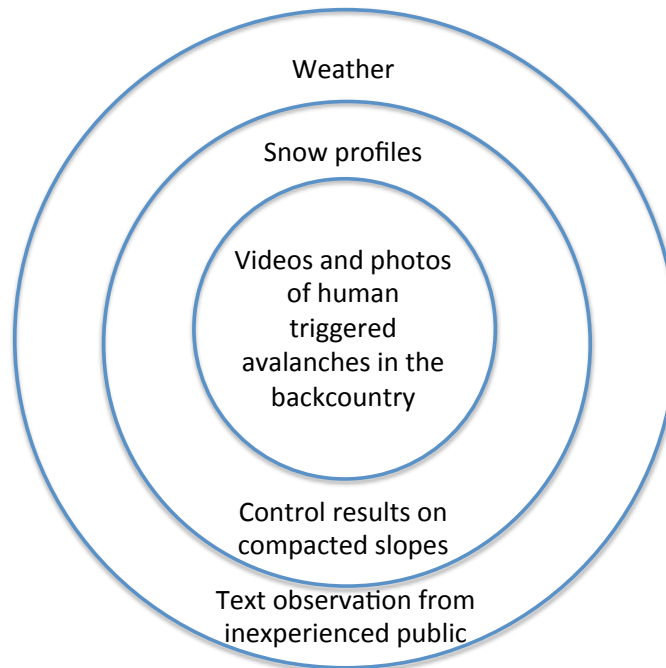


Fig. 2: Not all information carries the same value. High value information is what Fredston and Fesler (2011) call bull's eye information, such as a photo or video of a human triggered avalanche in the backcountry.

Update Belief based on New Information (Bayes Theorem)

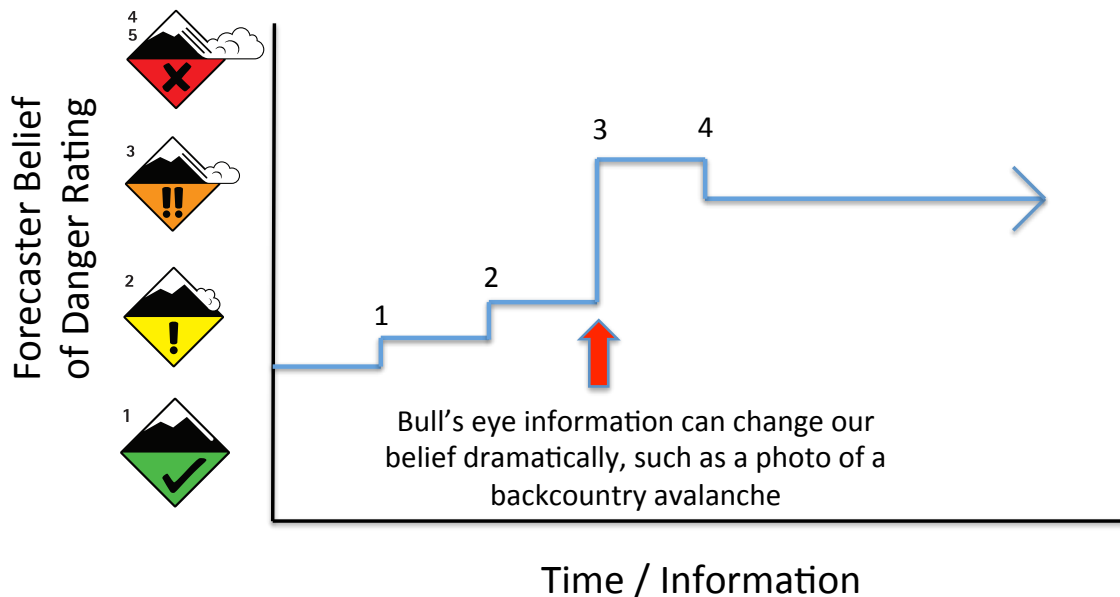


Fig. 3: If you are a forecaster struggling with what danger rating to use for the day, bull's eye information can change your belief very dramatically compared to lower valued information. A photo or video of a human triggered avalanche in the backcountry (3) is much more significant than lower value information (1,2 or 4) which will only elicit smaller changes in belief. This is a Bayesian process done intuitively by the forecaster.

Information from ski resort personnel who perform explosive avalanche mitigation has always been critically important to avalanche forecasting operations and continues to be so. Plus, ski patrollers are certainly very skilled and reliable observers. A limitation of information from control results is that they often come from well-compacted terrain where the critical weak layers responsible for backcountry avalanches no longer exist. Plus, ski resorts occupy only a very small geographic area, whereas we forecast for all the mountains of Utah, most of which do not have ski resorts.

Backcountry guiding operations, especially helicopter skiing, offer extremely valuable information because they operate in a backcountry setting, cover a wider geographic area and guides are highly skilled avalanche professionals used to dealing with a backcountry snowpack. Therefore,

we often talk with guiding operations by telephone on a daily basis, which is mutually valuable for both operations.

Still, we often find that the most useful information comes from either our volunteer observer network or the public for several reasons:

- Ski areas, highway operations and guiding operations operate in a very limited geographic area while the public recreate in a much wider geographic area—in every mountain range in the state. Plus, there are many more public recreationists than avalanche professionals so they provide boots on the ground in a vastly larger geographic area. (Fig. 4.)
- The public recreationists seem more than willing to go to all kinds of crazy places

and do all kinds of crazy things that avalanche professionals won't.

- Because we publish all observations on our website, it seems to set up an informal competition among the non-professionals to submit very high quality observations. Almost all include photos, and a surprising number contain videos and snow profiles. We are always amazed at what the public is willing to do for free.
- The public is ubiquitous and free while avalanche professionals are few and expensive.

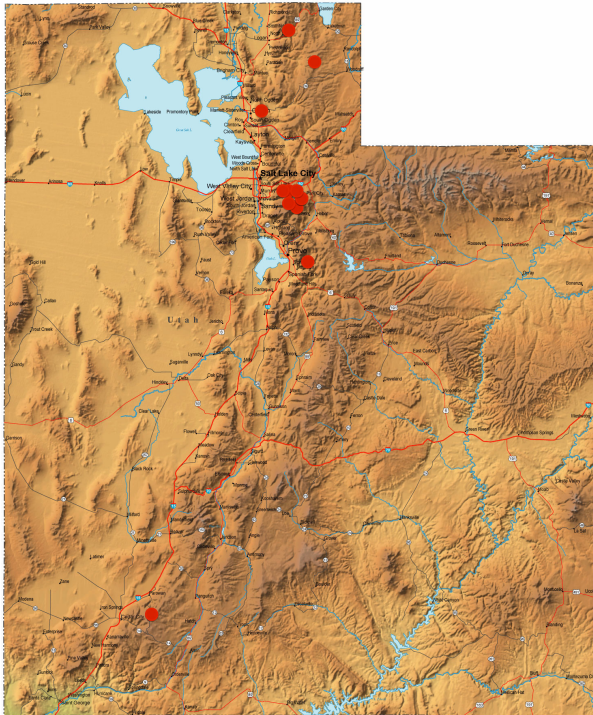


Fig. 4: A limitation with ski area explosive avalanche mitigation results is that they represent only a very limited geographic area (red dots) while we forecast for most of the mountainous areas of Utah. Plus, there are vastly more public recreationists than avalanche professionals, thus they cover a much wider geographic area.

As you might imagine, some information submitted by the public is suspect, especially from those with low avalanche skills. But we have found it fairly easy to read between the lines, size up the skill level of the observer and take it into account. Most observations submitted using our online form also include photos, and as we know, a picture

tells a thousand words, photos don't lie and they don't suffer from human foibles. We receive surprisingly very few observations that we decide not to publish. The bottom line: as long as they let us know about avalanche activity, how it was triggered, its location, and send us a good photo, we will gladly overlook any other suspect information. It's about the avalanches.

3.2 Social media

We have found that social media to be an extremely useful tool for two-way communication between forecasters, the public and traditional media sources such as television, radio and newspapers. Both Twitter and Instagram seem tailor-made for avalanche forecasting operations. We can both send and receive short messages along with photos or videos. They also help drive people to the website where they can both receive and submit more detailed information. We are co-located with the National Weather Service forecast office where the lead forecaster has a large screen above their desk that continuously monitors Tweetdeck, which is an important way they monitor rapidly changing conditions. Similarly, we also monitor Twitter and Instagram using both Tweetdeck and their feeds also automatically appear on the left margin of our observations page that our forecasters and users are able to monitor throughout the day.

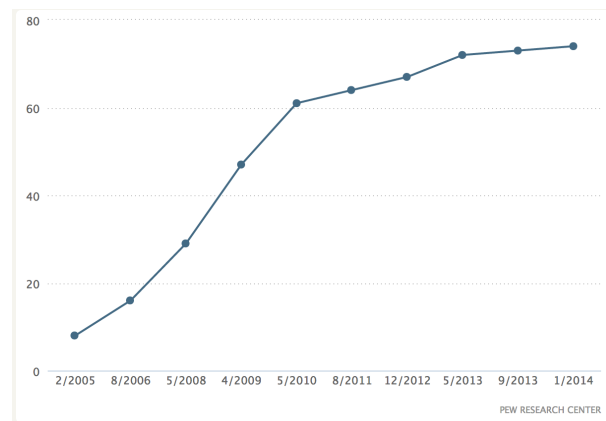


Fig. 5: Graph showing the percent of online adults who also use social media (74% in 2014). Source: Pew Research Center

Traditional media sources (TV, radio, newspapers) also closely monitor Twitter and Instagram feeds and often within a minute or two of when we tweet breaking news of a human triggered avalanche in the backcountry, they start calling our cell phones looking for more information. In this way, any

newsworthy activity quickly appears on media broadcasts or websites, which reach a far larger audience than ours. Plus, the information reaches an important target audience of people with lower avalanche knowledge and skills who don't normally monitor the Utah Avalanche Center website.

We utilize Facebook mainly for non-time-critical avalanche information such as for fundraising, avalanche awareness events and classes, educational information, and alerts of important blog posts. Occasionally people will use Facebook to let us know about avalanche activity as well.

Most other backcountry avalanche advisory services in North America also utilize crowdsourcing and social media (Table 1). Most of avalanche centers feel that observations from non-professionals are very important to their operation, especially at danger level 3 and higher while some feel that professional observations are most important and non-professional observations serve to augment them.

Granted, crowdsourcing may not work as well in some regions as others. Utah is unique in that a large mountain range exists close to large population center and Utah has a large population of avalanche-savvy, backcountry recreationists. For instance, we commonly receive real-time mid-morning observations from experienced users on backcountry dawn patrol outings before they go to work. Crowdsourcing may not work as well among populations with lower avalanche skills or very rural areas where few people recreate.

Crowd-sourced avalanche information seems like a good intermediate step for very rural areas where lack of population does not justify the expense of a professionally produced avalanche advisory. For instance, we plan to add a rural region to our observation network where local recreationists can post information to share with others. Last season, the Bridger-Teton Avalanche Center similarly added a rural region to their network and they feel it has worked well.

4. CONCLUSION

Crowd-sourced avalanche information and social media have both proven to work very well the Utah Avalanche Center and other U.S. avalanche centers.

Of the 1290 observation submitted to the Utah Avalanche Center public database last season, 72% came from non-professionals (27% from our volunteer observer program and 45% from the

Avalanche Center	% Observations from non-professionals	% of Observations containing either photos, videos or profiles
Gallatin	60	60
Bridger/Teton	70	55
Missoula	90	10
Sun Valley	25	26
Flathead	65	67
Idaho Panhandle	30	
Colorado	20	85
Utah	72	90

Table 1: A sampling of avalanche centers in our region and their estimated use of crowd-sourced data.

general public). Of 527 backcountry avalanches reported, 90% included photos and 12% included videos, which provide very high-value information both to forecasters who publish avalanche advisories and to the public who consume them.

We have found that observations submitted by non-professionals are surprisingly high quality. Even observations submitted by people with lower avalanche skills become very useful when accompanied by good photos of avalanche activity. In addition, there are vastly more non-professionals than professionals in the backcountry, they cover a much wider geographic area and they seem to be willing to go to riskier places and do riskier activities than professionals. Non-professional observations now comprise the bulk of useful information used to create the advisory.

Furthermore, by strongly encouraging the public to participate in the creation of the local avalanche bulletin, they feel included and take ownership in supporting the avalanche center not only with critical, backcountry observations, but financially.

Social media has become an important medium for two-way communication between the public, avalanche forecasters and traditional media outlets. Both Twitter and Instagram allow forecasters

and the public to exchange breaking news, photos and videos of avalanche activity. It also helps to drive people to the website for more detailed information and allow traditional news media to broadcast the avalanche message to a much wider audience.

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