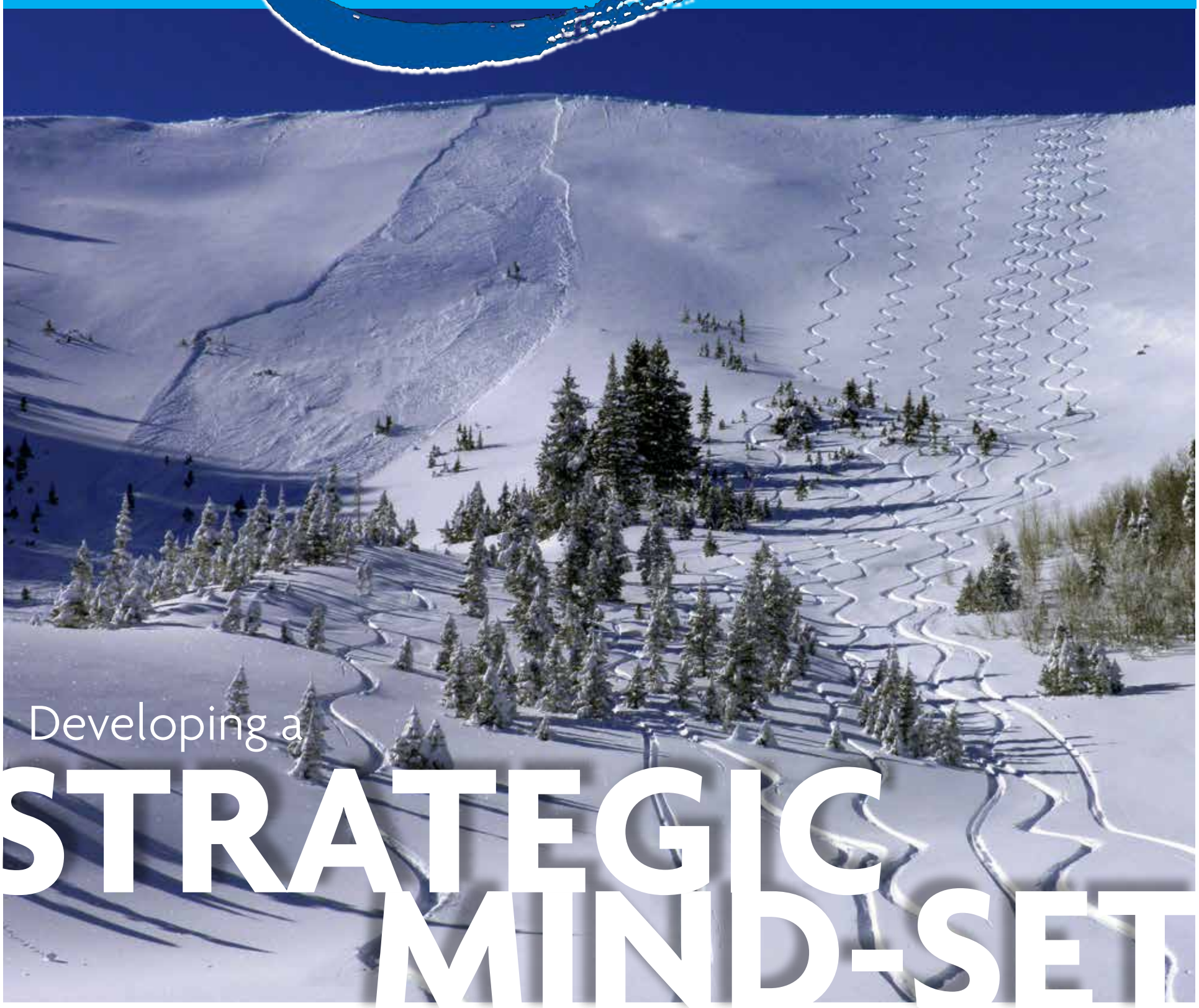
THE Avalanche REVIEW

A Publication of the American Avalanche Association®

VOLUME 33, NO. 4 • APRIL 2015

www.AmericanAvalancheAssociation.org



Developing a STRATEGIC MIND-SET

Photo by Mark White
Caption by Brett Kobernik, Utah Avalanche Center

WEST MONITOR AVALANCHE AND TRACKS: Most people look at this photo and think "**what the hell are these people doing?!**" Most people see the red flag we teach them to recognize: recent avalanches. This is the most obvious clue to avalanche danger.

Crazy? What if you knew there were no underlying persistent weak layers? What if you knew the exact timing of the avalanche? What if you knew the new snow had already settled out? What if you knew there was only minor avalanche activity from the new snow event? What if you knew the avalanche is where the most pronounced wind loading occurred? What if you knew the slope angle is less where the ski tracks are? You would only know this by following the snowpack and weather closely at this particular location, giving you the intimate knowledge which allows you to make such a decision.

To read a series of articles about human factors and decision-making, start with Roger Atkins' article Strategic Mind-Sets on page 18.

The Avalanche Review
P.O. Box 248
Victor, ID 83455

in this issue

Wisdom is largely a matter of selecting desires that are compatible with the conditions.

—Roger Atkins, Strategic Mind-Sets, pg. 18

THE Avalanche REVIEW

APRIL 2015 • VOL. 33 • NUMBER 4

The Avalanche Review is published each fall through spring by the American Avalanche Association, Inc., a nonprofit corporation. ***The Avalanche Review*** welcomes the submission of articles, photographs and illustrations.

Please send submissions to:
Lynne Wolfe — Editor
PO Box 1135
Driggs, Idaho 83422
tel: (208) 709-4073
lwolfe.avalanchereview@gmail.com

Advertising:
Paul Nordquist
1101 Lenore Drive
Tacoma, WA 98406
tel: (253) 830-4444
pwnordquist@gmail.com

Production:
McKenzie Long
PO Box 9368
Mammoth Lakes, CA 93546
tel: (513) 515-0723
mckenzie@cardinalinnovative.com

Business and Subscription Office:
Jaime Musnicki — AAA Executive Director
PO Box 248
Victor, ID 83455
tel: (307) 699-2049
aaa.jaimem@gmail.com
aaa@avalanche.org

Subscription: $30 per year (4 issues). Subscription is included with membership dues to AAA. For subscription and membership information, see **www.AmericanAvalancheAssociation.org**.

Contributions: Please submit material eight weeks prior to publication date. Include address and telephone number. Please submit typed manuscripts by e-mail or disk (CD or DVD), using any popular word processing program. Submit any figures as an EPS (preferred), PDF, TIFF or JPG file (300 dpi resolution at 100%). We will return materials if you include a stamped, self-addressed envelope.

Articles, including editorials, appearing in ***The Avalanche Review*** reflect the individual views of the authors and not the official points of view adopted by AAA or the organizations with which the authors are affiliated unless otherwise stated.

Layout & Design: McKenzie Long, Cardinal Innovative, (513) 515-0723, mckenzie@cardinalinnovative.com.

from the editor

You may have noticed that you received two copies of the February issue of The Avalanche Review, 33.3; our printer misprinted the first version so that the pages were badly out of order. They reprinted a corrected version and sent it out on their dime; we hope you enjoyed the corrected issue or passed it along to someone who might appreciate it. Next volume you'll find a complete redesign; full color glossy will better showcase the amazing photos that come in.

Now for the April TAR. Surface Hoar was a particularly persistent weak layer for us in the Tetons this winter, so I went looking for insight, both personally and to share with you. Bruce Jamieson, Doug Chabot, and Bill Anderson bring years of brainpower and tactics for managing and understanding the phenomenon, while John Fitzgerald, Garrett Seal, and Aaron Diamond have some impressive photos, starting on page 10.

We had a little extra room in this issue, so I put out a call for photos for the centerfold, a fabulous showcase for stories and snapshots from this winter and others. Thanks to everyone who responded; if your photo isn't in this issue, then we have it in reserve to adorn future issues.

As usual, the final issue of our winter volume revolves around human factors and decision-making, and this time we focus on how to create a strategic mind-set. The keynote article comes from Roger Atkins, who has clearly been thinking on this topic for quite some time. After reading his essay, you may want to add the task of choosing and clarifying the appropriate mind-set for the conditions into your trip planning protocol.

Mind-set reaches into every other article of the theme, as Doug Krause finishes his Situational Awareness trilogy with the final installment, Projection, giving the decision-maker more tools and tips for gaining expertise in a given environment. I've been using his progression (from perceptual to integration to projection) in advanced avalanche classes this winter; students seem to understand the steps and are able to articulate and improve on them in the field.

Philip Ebert builds on some of Doug's ideas and takes them into an examination of subtleties of competence, and how honesty regarding your own competence (or lack thereof) colors your mind-set. Emma Walker then explores her perspective on gender heuristic traps and how our gender may influence our decision-making.

Trent Meisenheimer dug deep to talk about a close call with his dad on Kessler Peak in Big Cottonwood. Once again, we see that, even if you think you share a mind-set, closing the circle of communication can make or break a day. (page 28)

In his trademark thoughtful avalanche-related prose, Blase Reardon brings us a couple of essays that explore the shifty nature of risk tolerance and the fact that risk is inherent in fully living our lives. Check out "Good Driver Discount" and "Got Religion Now" on page 27.

Mind-set and risk tie into topics I have been pondering over the winter. Right now I am reading Nassim Nicholas Taleb's book *Black Swan, the Impact of the Highly Improbable*, and gaining further insight and vocabulary around uncertainty. As we go to press I haven't finished it, but his insight into those Black Swan events is leading me towards setting up my expectations appropriately, designing my mind-set so that I have great days in the mountains, on both professional and personal levels. If his expertise couldn't keep consummate guide Robson Gmoser from dying on a Moderate- Low- Low day (March 11, 2015) then I need to make sure that I accept that Black Swan potential whenever I choose to put myself into complex terrain.

The avalanche community is gaining tools and insight from other fields of study over time. For example, over the winter, Don Sharaf has been giving a lecture on the topic of Margin in decision-making, using questions borrowed from wildland firefighting:

- Did we have a wide margin of safety or a narrow one?
- Did it change throughout the day?
- How did our decisions widen it or narrow it?
- What factors consistently narrow our margin?
- Are we making the same mistakes several times a season on days that we felt that little could have gone wrong?

These are the decisions/behaviors that we should change before non-events and near misses become accidents.

The overall question:

- How can we make decisions that foster a consistently wide margin when so many elements are beyond our control?

I look forward to exploring the concept of margin and learning to translate it into my practice in future issues of TAR.

As we bring those technologies and perspectives from other industries into our practices, we hope to gain insight not just into the environment, but also into ourselves. Ian McCammon reminds us in one of the Powder Magazine Human Factors videos that "every skill we have is balanced by a weakness." If we can understand our weaknesses and adjust our margins, we can walk with humility in the mountains for many years.

—Lynne Wolfe, Editor

from the president

Many of us are often presented with a similar question: *Why join the American Avalanche Association (AAA)?* Or more specifically: *What do I get out of it?* These are very legitimate questions and the easiest, most tangible answer is a subscription to *The Avalanche Review.* I could go on about what a great publication *The Avalanche Review* is, but I'll let you read on and decide for yourself. Back to the original question: what do you get for the $50 per year membership fee? For some of us $50 seems like quite a bit. I could take the NPR approach and tell you that your membership works out to 14 cents a day (far less than a cup of coffee), but I feel it means more than money. When you join, you are joining a community of professionals. It may not seem important at first, but it has meaning.

In my job I employ avalanche workers, and the first thing I look at on a perspective employee's application is whether they are a Professional member of the AAA in good standing. What that tells me is they have made the effort to become a member, remain a member, and likely they read and learn from *The Avalanche Review*. I sure hope your employer respects your membership as well.

As a community we are beginning to realize additional benefits. Our Executive Director recently attended the Outdoor Retailer's show and made some promising contacts with several outdoor companies. These potential partnerships may provide funding for AAA initiatives and also access to professional discounts for our members. I think it's great that our ED is seeking out direct benefits for you as an existing or prospective member.

But as important as it is to get something for being a member, it is just as important to give something. Recall those famous words from President Kennedy's inaugural address: "ask not what your country can do for you; ask what you can do for your country." That very idea brings me back to the theme of community and joining a community of avalanche professionals. Our former AAA President Dale Atkins set forth those ideas when he said the American Avalanche Association stands for Community, Knowledge, and Professionalism. When you join the AAA you bring your knowledge and professionalism to our community. Your knowledge and professionalism are what make our community so strong. You set the example in your workplace and out on the snow. Take a look through the list of professional members. I for one am honored and humbled to be included on a list that includes so many outstanding men and women. After you've finished reading this edition of *The Avalanche Review* please take a moment and encourage a non-member friend or co-worker to join this community of avalanche professionals. Thank you, enjoy some spring skiing, and I look forward to seeing you next fall.

—John Stimberis, President

letter to the editor

Explosives as a Tool; not a Test

By Michael Leatherbee and Dick Penniman

At the 2014 ISSW in Banff, we presented a paper entitled, "A Tool, not a Test: The Use of Explosives in Avalanche Hazard Assessment." Because of some comments made in *The Avalanche Review*, and a few that were heard during the poster session where the paper was presented, we feel a need to respond to emphasize some of our points.

In his article, "For the Peanut Butter and Jelly Crowd" (TAR 33.2, December 2014), Doug Richmond quotes our paper, saying that we are promoting the idea that any time explosives are used and an avalanche doesn't occur, the terrain should be closed to public access. In our paper, our intention and what we say is that when the use of explosives fails to trigger an avalanche, opening the terrain to the public may be justified as long as the other critical data are all consistent with the original hazard forecast.

The central point we make in our paper is this: When the hazard forecast calls for "significant" uncertainty about the instability of the snowpack (however one chooses to define it), and explosives fail to trigger expected avalanches, the only logical conclusion that can be drawn is that either the forecast was wrong or the explosives use was faulty in timing, placement, and/or strength. In our paper we argue that any such discrepancy should be acknowledged and resolved using the best and most persuasive data possible before the suspect terrain is opened to public use. We argue that in the interest of public safety, relying on the failure of explosives to trigger avalanches alone to justify opening highly suspect avalanche terrain does not constitute sound decision-making.

This brings us to the issue presented in our paper to which Richmond objected most strongly; our proposition to replace the term "test" by the term "tool" when referring to explosives use in avalanche hazard assessment. Since first being used to trigger avalanches, most avalanche professionals have referred to explosives as "instability tests" or—less appropriately—as "stability tests." In our research, we found that the most common use of the word "test," and the one most likely to be understood in the context of explosives use in avalanche work can be paraphrased as simply "an examination to prove the nature of something." Explosives do not prove anything about the snowpack unless an avalanche is triggered (in which case snowpack *instability* is confirmed). Post-control avalanches have shown this to be true time and again. Therefore, explosives alone should not be considered "tests" of snowpack *stability* when lives are at stake.

A "test" offers "proof" that can be used to make sound decisions. In contrast, a "tool" is simply a device to try to achieve an end. In our paper we use the example of a wood saw; a tool that cuts wood very effectively. However, when used to try to cut steel, it fails. This failure does not lead rational thinkers to conclude that the steel cannot be cut. Using the wood saw is not a "test" of the steel's ability to be cut; it is simply the wrong "tool" for the job.

Analogously, when a significant avalanche hazard is forecast and explosives fail to trigger the expected avalanche(s), this failure does not constitute proof that the snowpack will not avalanche by some other means. A group of skiers may be a better tool for that job. We've concluded that all post-control avalanche fatality events at ski areas in recent years have occurred as a consequence of significant instability in the snowpack and a failure of explosives to trigger the impending avalanche. Among others, these include the Canyons avalanche referred to by Liam Fitzgerald in the September 2014 issue of *The Avalanche Review*, and an avalanche fatality at Jackson Hole on December 27, 2008.

Changing old habits is hard business. Changing the words we use may seem trivial and pointless, especially when we think everybody else already understands what we are saying. Inevitably, however, words can convey different messages for the person uttering them, and for the person receiving them. When avalanche experts inform the decision-makers in management that they have conducted "stability tests" with explosives and have observed "no avalanche activity", what is often heard is "the slopes are safe to open." The point we make in our paper is that changing a single word in the message—and thereby minimizing the potential for bias in the interpretation of the message—offers a means to get avalanche forecasters, field technicians, and management decision-makers to sing from the same hymnal.

There have been instances when decisions to open suspect slopes to the public have been made under pressure from management on the biased assumption that the explosives were a proper "test," and the incorrect belief that their failure to trigger the expected avalanche proved the slopes to be stable when, in fact, they were not. Explaining to management that explosives are merely "tools" that don't always do the job we want them to do should allow those responsible for avalanche hazard assessment to justify a higher level of public safety in the face of business pressures. When the forecast is for a significant avalanche hazard and the explosives "tool" fails to trigger expected avalanches, the seemingly appropriate response is to admit that this failure alone is not proof that the slopes are reasonably safe for public use. Conveying this message to management may make it easier to ask for more time to gather additional data; to go back out and throw more effective shots; or to keep certain slopes closed until enough additional observations allow for a sound decision to open that terrain.

Nobody wants a post-control avalanche fatality on his or her watch. There have been far too many in recent years. Those responsible for avalanche hazard assessment must accept the responsibility of minimizing the risk for those in their charge who have neither the training nor the skills to do so for themselves. By simply changing a single word in their professional vocabulary they can correct the message they convey to those less knowledgeable than themselves. In turn, delivering an unbiased message may provide the necessary latitude from management to achieve a higher level of professionalism. The snowpack can't always be controlled. But when there is significant uncertainty, avalanche professionals have a duty to those who entrust them with their lives and the lives of their family, to control access into suspect avalanche terrain.

Note: **The full text of our paper can be found here:**
arc.lib.montana.edu/snow_science/objects/ISSW14_papaer_P2.33.pdf

Michael Leatherbee holds a Ph.D.(c) at Stanford University and is Assistant Professor of Entrepreneurship, Strategy and Innovation at Pontificia Universidad Católica de Chile. He advises the Chilean Government on the topics of innovation and entrepreneurship, and El Colorado Ski Resort (Chile's largest) on topics of strategy.

Dick Penniman is an Avalanche Safety Consultant and is past Assistant Ski Patrol Director for Alpine Meadows (CA), past Ski Patrol Director at White Pine (WY) and Sugar Bowl (CA), and past Mountain Manager for El Colorado Ski Resort (Chile). He has also directed avalanche forecasting and control operations for Enserch Exploration (AK) and Granite Construction (CA). He is currently the Avalanche Forecaster for Washoe County (NV) in north Lake Tahoe.

what's new

Nick Meyers: cover model.

Back in December, I got an email from John C. Heil III, Press Officer, Public Affairs and Communications for the Forest Service Pacific Southwest Regional Office. As I understand, Kevin Depzyk, Editor for *Popular Mechanics*, emailed or called John and inquired:

> **So here's what we're looking for: we want to try and spotlight a few people who have jobs that mean they put survival skills in practice on a regular basis. We'd like it to be someone who is out in the field regularly, and, at least on occasion, out for days or weeks at a time. We want them to be able to tell some good stories, recommend equipment they couldn't live without (not brand-specific), and give some good practical advice.**

Somehow, the request filtered down to me. I responded to both Kevin and John and said I'd be happy to accommodate. I ended up conducting a full interview, and *Popular Mechanics* sent up a photographer for a photo shoot. I also did a podcast with Kevin about a rescue story.

The resulting article is pretty good. There are a few things that I would have changed, but overall, it's good. It is short and basic, and has a good message. As Karl mentioned, if the media gets it 90% right, or thereabouts, then that's acceptable!

—Nick Meyers

Read the full article and listen to the podcast here:
http://www.popularmechanics.com/technology/gear/a14355/10-survival-essentials-an-avalanche-rescue-experts-always-carries/

Falling Snowflakes: a pancake pan.

By Barb Garrett and Halsted "Hacksaw" Morris

Usually *The Avalanche Review* does not do equipment reviews, but recently I came across an item that all "snow nerds" should consider purchasing. The Nordic Ware Falling Snowflake pancake makes seven silver dollar size pancakes and is made of high-grade cast aluminium.

The only negative point of this product is that two of the stellar crystal outlines have seven points rather than the normal six, but that can be remedied with a fork and some syrup. www.nordicware.com

SAW REPORTS

Snow & Avalanche Workshops

Booth at USAW.

USAW 2014

By Paul Diegel

On Saturday, November 1, 2014, about 470 avalanche pros and 150 high-level backcountry recreationists came together at the Southtowne Expo Center in Sandy, UT for the 7th annual Utah Snow and Avalanche Workshop (USAW). The morning session was open to avalanche professionals in order to allow more open discussion about potentially sensitive topics and to allow greater focus on professional-oriented topics like workplace safety and resort and highway issues. The afternoon session was open to the public and was more oriented towards issues of general backcountry interest. The complete presentation agenda:

- **Randy Trover:** Changing of the Guard- Lessons learned from past administrations.
- **Brint Markle and Thomas Laakso:** AvaTech- A high tech snowpack measurement device with data collection, networking, and analytics capabilities.
- **Bob Comey:** Jackson Expansion- A comparison of avalanche hazard mitigation methodologies.
- **Peter Schory:** Artillery, Avalaunchers, Explosives, and the Snowy Torrents… an Overview- Updates on the AAUNAC organization/members, NSAA explosive committee members and purpose, along with a call for a new edition of The Snowy Torrents.
- **Scotty Savage:** Survey of Avalanche Professionals- An institutional and personal analysis of accident causes.
- **Matthew Edward Jeglum:** A Changing Planet-Potential Impacts of Climate Change on Avalanche Characteristics and Forecasting.
- **Alex Marienthal:** Deep Slabs- Meteorological variables associated with deep slab avalanche on persistent weak layers.
- **Brian Pollick:** Deep slab instabilities at Powder Mountain- Summary of a historic avalanche cycle.
- **Jason Konigsberg:** Avalanche Forecasting at the Club Fields of New Zealand. Challenges and intricacies of opening ski terrain and forecasting for roads accessing the unique club fields of New Zealand.
- **Craig Gordon:** Utah Winter Review 2013-14. A look back at the events that shaped the winter of 2013-14
- **Andy Paradis:** Persistent Weak Layers- Using voluntary avalanche reports to identify the longevity of weak layers and how it translates to human triggered avalanches.
- **Craig Gordon:** Gimme Shelter- A physical, spiritual, and psychological review of a historic avalanche cycle in the western Uinta Mountains.
- **Jordy Hendrikx:** A crowd sourced approach to understand decision making in avalanche terrain- We will present the results from our 2013/14 season of global data collection examining decision making in the back country.
- **Ben Pritchett:** Insights into the Future of Avalanche Education- We'll share and discuss a current proposal to revise the US avalanche education track to better target each student's needs.
- **Alex Do and Bob Comey:** Puckerface- Human factors lead to a tragic avalanche accident in the Jackson Hole backcountry.
- **Matt Morgan:** Northern Bear Range Avalanche Accident- A day of snowmobiling turns into a struggle to save a rider's life.
- **Linda Andrus:** Fairy Meadows- A review of an avalanche accident in a remote mountain setting.
- **Scott McIntosh MD, MPH and George Vargyas ,MD:** Avalanche Victims and Trauma: Updates and Application- An updated review of traumatic injury incurred by avalanche victims with practical caveats for on-site management.
- **Drew Hardesty and Laynee Jones:** How the Freedom of the Hills has Become Anarchy in the Backcountry- A look at the Past, Present and Future of Freeriding in the backcountry.
- **Jim Steenburgh, PhD:** Secrets of Wasatch Snow- A new book exposing the myths and explaining the reality of deep powder and mountain weather in Utah and around the world. See book report by Jake Hutchinson on page 31 of this issue.

Huge thanks go out to the 30 sponsors who make an affordable workshop of this level possible, including the title sponsor, XInsurance. USAW 2015 will be held on October 31 and will be a great way to celebrate Halloween.

Attendees at NRASW. *Photo by GlacierWorld.com*

NRASW

By Ted Steiner & Erich Peitzsch

On October 22, 2014, the fourth annual Northern Rockies Avalanche Safety Workshop (NRASW), a one-day regional avalanche safety gathering, took place in Whitefish, Montana. Logistically, the day of the Workshop was not optimal for all as it coincided with the opening of Montana's big game rifle season and was the day after the Gallatin National Forest Avalanche Center's fundraiser. Due to these scheduling conflicts, those of us on the Organizing Committee wondered how attendance would compare to years past. Fortunately, it appears big game hunting had little effect on the workshop and attendee numbers from the Bozeman area were strong. This year's attendance topped 220 and many attendees mentioned it was the best workshop so far. However, for those concerned, the Organizing Committee will do its best in the future to not conflict with hunting or avalanche center fundraising.

As in the past, this year's gathering featured guest speakers, vendor displays/demonstrations, raffle prizes, and approximately 200 attendees. The Workshop audience was comprised of winter backcountry enthusiasts and avalanche industry professionals from Montana and Idaho.

The emphasis of this year's workshop was once again focused on introducing and discussing skills, resources, and case studies focused on improving avalanche risk assessment, management, and reducing one's vulnerability to avalanches.

Five presenters assisted us this year and all are currently working in the professional arena of avalanche forecasting, avalanche education, and climate change in the United States.

Presenters included:

- **Erich Peitzsch**, Avalanche Specialist, Director of the Flathead Avalanche Center, northwest Montana.
- **Simon Trautman**, Avalanche Specialist, National Avalanche Center.
- **Tom Murphy,** American Institute for Avalanche Research and Education co-founder, Crested Butte, Colorado.
- **Greg Pederson**, USGS Research Scientist, Northern Rocky Mountain Science Center, Bozeman, Montana.
- **Steve Karkanen**, Director of the West Central Avalanche Center, Missoula, Montana.

Each presenter spoke for 40 minutes with 20 minutes available for questions from attendees. Each presentation balanced well with the workshop's main theme.

Following individual presentations a one-hour panel discussion with the theme of "Managing Avalanche Risk in High Traffic Backcountry Areas" ensued. This panel discussion, although it had a theme, was open to questions and dialogue from the workshop attendees. Panelists included most workshop presenters along with Daniel Howlett (Howie) of RECCO/Alta Snow Safety and Ted Steiner, BNSF Railway Avalanche Safety. The inclusion of the panel discussion was new and also well received by the workshop attendees.

Following the classroom portion of the Workshop an after-event social, which was sponsored by the Friends of the Flathead Avalanche Center (FOFAC), took place at the Great Northern Bar in Whitefish. This event allowed for hydration after a hard day in the classroom, socializing, and lively discussion of the day's workshop presentation topics. Thank you so much to FOFAC for sponsoring this fun event.

Organizing the 2014 NRASW began in early spring and was progressively molded by monthly meetings of the volunteer organizing committee until the workshop commenced in October. We were fortunate again this season to have a solid and dedicated organizing committee. This was a huge dedication of volunteer time and effort. Thank you to all that assisted with organizing. Particular recognition is due to Amy Moore, who was this year's chair of the organizing committee and responsible for the awesome workshop website: **www.avalanchesafetyworkshop.com**

Sponsors played a huge role in providing financial assistance to NRASW 2014. Once again, as in all workshop years, the American Avalanche Association (AAA) was our first sponsor to step in and provide seed money for the event. From the NRASW organizing committee to the AAA Board and membership, thank you so very much for your financial assistance.

We would also like to recognize additional non-profit based financial assistance for the workshop provided by the Flathead Nordic Backcountry Patrol (FNBP), the Big Mountain Ski Patrol, the National Ski Patrol, and the Whitefish Community Foundation.

Local retailers as well as nationally based avalanche safety equipment manufactures also sponsored the event. Both financial and in-kind sponsors contributed funds and/or equipment (for raffle) to the workshop and were critical for its overwhelming success. A list of NRASW 2014 sponsors can be found at: www.avalanchesafetyworkshop.com

NRASW 2014 was once again a "net zero" event with all income that exceeded event expenses being retained for the next season's NRASW or donated back to the local avalanche safety community. Funds in excess of expenses for NRASW 2013 were utilized to assist local non-profits with avalanche education, information, and rescue resources. A significant portion of these additional funds ($5000) was utilized to provide partnership monies for a publicly accessible automated weather station that is now functioning on the summit of the Big Mountain (Whitefish Mountain Resort).

Although NRASW 2015 is currently on the docket to once again happen next fall, a significant change will be that the management will transition from what has been a private, "for-profit" event to the volunteer run non-profit Friends of the Flathead Avalanche Center. The existing organizing committee will assist with the transition and organization of next year's workshop.

We look forward to hosting the NRASW again in 2015 and hope to see you there!

—Ted Steiner & Erich Peitzsch,NRASW Organizing Committee

what's new

Whitefish Women's Avalanche Class

Here are some fun photos of our recent awareness course on Whitefish Mountain Resort. The course filled in the first 24 hours. We had to turn ladies away at 20. The course was free to all participants. We had a wide age range from 24-61. Mode of transport was skis, snowboards and snowshoes. Six women instructed the course, all donating their time. I was the lead instructor.

Sponsors: Flathead Avalanche Center, Friends of the Flathead Avalanche Center (FoFAC), USFS, Whitefish Mountain Resort, Big Mountain Ski Patrol, Crested Butte Outdoors.

Read about the course: http://www.outsiety.com/girls-getting-rad.

—Sue Purvis

Practice Meets Science: SLF International Advanced Training Course on Snow and Avalanches in Davos Switzerland

By Tim Glassett

Jakobshorn ski patroller explaining the different methods of avalanche artificial release used. *Photos by Tim Glassett*

After traveling 23 hrs on three different flights and ending up in the Zurich main train hub; I watched dozens of people walking onto trains in ski boots with skis in hand. Jetlagged, I realized I was no longer in Alaska. As of this writing, winter 2015 for the Seward Highway has been the lowest on record for snow accumulation and 2nd lowest for snow water equivalent for our 32-year dataset. This in part made it possible to attend the Institute for Snow and Avalanche Research (SLF) "Practice meets Science" international advanced training course on snow and avalanches in Davos, Switzerland.

This course was the first international training of this kind the SLF has put on. Participants came from Andorra, Austria, Chile, France, Japan, Netherlands, Norway, Poland, Sweden, Switzerland, Spain, and from the United States. Participants had varied backgrounds including civil engineers, PHDs, researchers, rescue workers, guides, and avalanche forecasters for roads, mines, and public centers.

How does this course compare to US avalanche education?

Full disclosure, the last avalanche class I took was a level 3 from the Alaska Avalanche School and AAI in 2011. I have not attended an AVPRO or the National Avalanche School and do not hold a degree in snow or avalanche sciences. In my opinion this course covered topics that one does not receive in standard US avalanche education.

Course topics for days 1 and 2 included; avalanche formation, snow physics, best practices in avalanche forecasting, limitations of forecasts, interpretation of data, remote sensing tools, avalanche detection, standard procedures for snow profile observations and stability tests, and snow profile interpretation. For days 1 and 2 all participants had the same topics. The field day consisted of standard snow profile observations and tests. Of note, the SLF teaches and uses the Ram penetrometer in addition to a hand hardness test for their observer network. I also found a difference in the loading steps and use of the Rutschblock. In the SWAG loading steps RB4-6 jumps are in the same compacted spot. The Swiss move off the block and jump from above. The Rutschblock test is highly regarded and commonly used in the field. When was the last time you dug a Rutschblock?

Day 3, topics for the morning were avalanche history and development of mitigation measures in Davos, avalanche dynamics, avalanche hazard mapping, human factors, wet and glide-snow avalanches. In the afternoon the participants were split into two modules. Module 1, snow stability and avalanche forecasting; topics were consistent with a level 3 avalanche class. Module 2, avalanche safety and control, was the module I was interested in. Topics included; overview on the application and design of snow supporting structures, temporary protective measures, local hazard assessment and artificial avalanche release. This was followed by a case study exercise of closing an alpine road.

Day 4, Module 2 topics were avalanche safety concepts, experience of a local avalanche service in the Upper Engadine, overview on the application and design of avalanche dams, snow sheds and snow drift measures, methods of artificial avalanche release, snow supporting structures, hazard mapping case study, and discussion about permanent and temporary protection measures. In the field we visited Jakobshorn, a local ski area, and toured the many defensive structures in the Davos region.

Final day (5), Module 2 topics covered RAMMS the rapid mass movement system, practical use of avalanche modeling, synthesis of the course, final discussion, and a RAMMS workshop.

Highlights

I would describe this training as an intimate ISSW. As a practitioner learning from one of the leading research and development institutes in the world it was priceless. The instructor core included the director of the SLF, J. Schweizer, as well as S. Margreth, L. Stoffel, A. von Herwijnen, K. Winkler, C. Pielmeier, to name a

Snow bridges on the Schiahorn provide protection for Davos Dorf, Switzerland.

few. All instructors are leaders in their area of expertise.

As an avalanche worker on roads many of the exercises and practical applications of SLF practices are directly applicable to my work. In addition the connections and conversations with other practitioners have already been fruitful for solutions to problems on our roads.

Module 2 allowed me to gain insight into hazard mapping, comparison design and use of avalanche protective measures that have been employed in Switzerland. The presentation by Jon Andri Bisaz was especially enlightening. He works in the avalanche safety service which is responsible for roads, rails, and a town in the Engadin valley. The program employs mortars, Daisybell, Wyssen towers, and heli-bombing for avalanche reduction. In addition he is using a human and animal detection tower equipped with radar, webcams, and an IR camera to determine if a starting zone is clear before reducing the avalanche hazard. Touring Jakobshorn ski area was also educational. This area has 12 ski lifts, 3,400 feet vertical drop, and 30 miles of ski runs. They reduce the avalanche hazard to their marked ski runs using a bazooka, hand charges, 4 Gazex, Wyssen tower, heli-bombing, and avalanche pipes. The ski patrol on staff during the week is 4 and 6 during the weekend. I was told this limited staffing is common in Switzerland, but larger ski areas do employ several more patrollers.

This course was focused on the professional avalanche worker, and catered to different aspects of the profession. It did not have rescue training. For an advanced professional course, rescue training could be a prerequisite and not necessarily practiced in the course. This may have allowed more time to focus on applications of theory.

I would like to thank M. Murphy, D. Sanders and T. Grman for help in attending this course and Frank and Esther for their hospitality in Davos.

Finally, if you like excellent Swiss three-course lunches, they're provided! Just remember which forks and spoons go to which dish.

Tim Glassett works as an avalanche specialist for Alaska DOT&PF's Seward Highway Avalanche Program. While in Switzerland he was happy to investigate the local avalanche reduction methods. He can be reached at ***timothy.glassett@alaska.gov.*** ❄

I really couldn't help myself when I learned they use bazookas over there. I had to get a picture.

The 2015 National Avalanche School: A Professional Training Program

By Janet Kellam

The National Avalanche School, the nation's oldest and most acclaimed avalanche training program for snow safety professionals, holds its 24th session beginning October 25th at Snowbird, Utah. The 2015 School will have a number of updates and is oriented specifically for ski patrollers, avalanche forecasters, avalanche center observers, mitigation specialists, mountain managers, agency land managers and others who work in an operational setting. Guides and educators can also benefit from the unique opportunity to learn from and engage with a number of leading U.S. experts in a variety of settings.

NAS instructors are not only excellent teachers; they are leading avalanche professionals with decades of experience working in the industry. NAS instructors have trained and mentored hundreds of today's professionals. Check the roster, it speaks for itself. With the likes of Karl Birkeland, Ethan Greene, Bruce Tremper, Craig Sterbenz, Knox Williams, Paul Baugher and others, students benefit greatly from the experience.

The NAS provides students with a solid foundation of avalanche fundamentals applied to both backcountry and ski area snowpacks. It goes one step further, recognizing that patrollers are tasked with the serious job of actively dealing with and reducing avalanche problems in avalanche terrain. Because of this, the NAS includes additional topics oriented to ski area operations, unique problem solving exercises, and case studies presented by the professionals who were on site and in the hot seat during avalanche events. All this contributes to a remarkable professional training opportunity.

The School is structured with a four-day October classroom session and a four-day mid-winter field session. This allows students to interact with all of the instructors from throughout the western US during the classroom portion, then during the field session students work in very small groups with a mix of some of the classroom instructors, regional instructors and ski area avalanche staff. Students are tested, coached and evaluated for competency and skills throughout the school. Of great value, students develop professional relationships with instructors and other students that can last throughout their careers.

To guarantee a truly professional training program, the NAS continues to strongly recommend that all students have some prior experience and training before attending the School and provide a simple reference with contact information from a supervisor, mentor or avalanche professional. Students should have completed a level one recreational avalanche course or comparable work training, and companion rescue training and practice. With its standard curriculum, updates and suggested prerequisites, the National Avalanche School is on track to meet and exceed the American Avalanche Association's proposal for US Avalanche Worker Training programs in 2016.

The NAS is not just for patrollers early in their career, the NAS provides an excellent refresher and contemporary updates for experienced, seasoned avalanche workers. Check **avalancheschool.org** for 2015 curriculum, instructors and registration. It's worth noting there is an early registration price incentive.

The National Avalanche Foundation oversees the National Avalanche School in partnership with NSAA, The USFS National Avalanche Center and National Ski Patrol, and works in conjunction with the NAS Instructor's Steering Committee.

Janet is former director and forecaster for the Sawtooth Avalanche Center and has been an instructor at the National Avalanche School since 1999, where she is currently the Program Director. ❄

Know Before You Go Update

By Paul Diegel

The Utah Avalanche Center is revising the Know Before You Go avalanche awareness program and is looking for help to produce a new introductory video and presentation slide deck for Fall 2015 release. The KBYG program introduces avalanche awareness to new and prospective backcountry users and provides the first exposure to avalanche issues for many people. This program is aimed at backcountry and sidecountry skiers and snowboarders, snowmobilers, hikers, fat bikers – anyone new to the backcountry. The intent is to make them aware of the hazards they face and how they can mitigate those with education and an understanding of how avalanches work. The intent is to lead those who will become regular backcountry users to the existing avalanche education track and those who become occasional users to avalanche advisories and practicing simple risk-reduction steps.

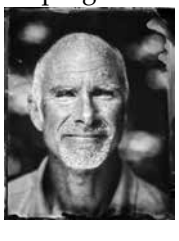
The KBYG program was developed by the Utah Avalanche Center in 2004 to address the lack of basic avalanche awareness among inexperienced and potential backcountry users. Since inception, nearly 200,000 Utahns have seen the presentation along with many more around North America. For many backcountry users and potential users, a KBYG presentation is their first exposure to avalanche education. The program begins with an video intended to grab the viewer's attention and convey the destructive nature of avalanches and the message that avalanche knowledge allows us to get out and have fun in and around avalanche terrain safely by following some simple rules. The follow-up slide deck allows the presenter to explain in more detail how backcountry skiers, snowboarders, snowmobilers, and hikers can safely pursue their passion in the mountains. The program ends with a Q&A session and is intended to fit into a 50-minute class period. While originally intended for a school-age audience, the program is popular at ski and snowboard shops and clubs, community centers, and more.

The KBYG program has become a cornerstone of the Utah Avalanche Center operations – we present this over 160 times per year, providing opportunities for avalanche professionals to leverage their knowledge, educate the public, and earn a little extra. Other centers around the world have picked up the program as well.

The program competes with sophisticated messaging for user attention and relies on current video footage, music, editing, and gear placement and pro athlete endorsement to remain relevant and compelling. We are producing a new video with updated content and updating the slide deck, along with preparing an instructor training program and a tool kit for helping avalanche centers fund and administer delivery of the program. A second goal is to create content more relevant across North America, showcasing different terrain and regional issues. The program content is open source and available for free to anyone wanting to present it. We also can provide advice on how we have managed logistics like marketing the program to local school and shops and tapping into local foundations for funding to pay for managing and presenting the program

We released a related video in fall 2014 specifically for raising awareness among motorized users that can be viewed at **https://vimeo.com/113677686**. The existing 10-year-old KBYG video can be viewed at **http://vimeo.com/61441476**.

We are in the process of collecting footage and storyboarding the program now and are looking for financial support, offering business and avalanche centers logo and product placement in the video in exchange for donations to offset the cost of producing the program. We are also seeking high quality video footage of iconic local terrain, recognized athletes, and local thought leaders telling their stories. Anyone interested in providing support should contact us right away and anyone interested in getting the content and bringing the KBYG program to their area should watch for a launch announcement in the fall.



Paul is the Executive Director of the non-profit Utah Avalanche Center, a recovering biomedical engineer, and has been playing in the backcountry since shortly after birth, on foot, skis, splitboard, mountain bike, and kayak. ❄

education

The Importance of Methodical Probing for Rescuers

By Jason Konigsberg

During the month of January and constant high pressure, a co-worker and I conducted 65 beacon drills with professional ski patrollers. We did not intend our beacon training to be any sort of scientific research and did not foresee that the results of this training would be worth writing a paper about or a TAR article. However we found some common mistakes among professionals that would be worth sharing with the avalanche community.

For fun, we formatted our beacon drills into a competition amongst the patrol. During the initial round a pack was buried approximately 40-60cms deep and each patroller was required to conduct a beacon search, get a positive probe strike, and then dig up the pack to stop the clock. We took the best times from the initial round and had ten patrollers compete in a final round where we had two beacons buried. One beacon was moderately deep with the lowest signal ranging between 1.3 and 1.5 meters. This beacon was buried with a piece of plywood on top for a probe board. The second beacon was buried between 40-60cms deep and was inside an easily probable pack. The clock stopped when the patroller probed both targets (no shoveling in this scenario).

Almost all patrollers had no problem during the signal search and the coarse search with their beacon. During the fine search, experienced patrollers excelled where patrollers with limited experience had room for improvement. During the probing phase of the beacon search, almost all patrollers would stumble, independent of experience level, if they did not get an immediate probe strike (first 1-3 probe attempts).

The common theme was that if there was no immediate positive probe strike the searcher would become nervous and second guess the validity of their fine search. The searcher would then abandon additional probe attempts and revert to a fine search to again confirm the lowest signal. The searcher would then probe an additional few times and again become nervous with no positive probe strike and again resume a fine search to confirm the lowest signal. This cycle resulted in anywhere from one to two minutes in lost time that could have been avoided.

The results of our testing reinforced the importance of a methodical approach to probing, preferably the spiral probing technique with 25cm spacing as written about by Genswein. Most importantly we found that once the lowest signal has been obtained by the searcher, the beacon should go away and stay away. Experienced searchers who second guessed themselves wound up back at the same point where they started; their original fine search was accurate and a second check was unnecessary. Methodical probing would have saved much time over the second and third confirmation of the lowest point in a fine search with a beacon.

Much of what this article covers has already been written about in research papers in the past and there is no new technique that needs to be incorporated. It has been well documented that as beacon technology has advanced, educators should not only focus on the beacon portion of the rescue but on strategic probing and shoveling as well. The take-home point for seasoned searchers is to trust your fine search, put your beacon away, and probe methodically to cut valuable time off your search. Although we all have learned this and know what we are supposed to do, we were able to see what mistakes were made by professionals in a situation with pressure (there was patrol pride on the line as well as prizes provided by Black Diamond/Pieps). Due to our findings we have started to adjust the way we conduct everyday beacon practice. We are shifting to include probable targets instead of burying beacons in small, hard to probe, PVC tubes or containers. Our old method was effective in conducting very quick beacon drills even during busy times patrolling but taking a few extra minutes to bury a probable target for beacon drills may be well worthwhile as this training can save crucial minutes in a real burial situation. Hopefully this information can help other professional rescuers improve their search skills.

Thanks to Pete Earle (Canyons Resort Snow Safety) for helping to conduct testing and evaluate results and Ryan Guess from Black Diamond/Pieps for providing prizes for the winners.

Jason is part of the snow safety team at Canyons Resort and an instructor for the American Avalanche Institute. ⁂

High Resolution Snow Stratigraphy: Part 2

By Steve Conger

February 2015: As you survey the mountainside, the winter mantle of snow is continuous and appears stationary. Everywhere you are looking (unless you are lucky enough to be witnessing an avalanche) the snow is in fact stable. Somewhere behind that stationary facade the snowcover is stressing like rails spiked to aging ties in loose roadbed under a hundred car coal train just easing into the descent to a valley miles and countless steep grades away. Elsewhere weak layers or interfaces within the snowpack lie concealed and threaten eruption like guerrilla attacks in an ethnic conflict rooted centuries ago.

The very nature of this "hiddenness" of critical information that helps prediction of current and future avalanche hazard or risk over time and space has been the focus of avalanche research since the beginning. Digging and testing the local behaviour of the snow is the standard method of overcoming the hiddenness of this information. Observing the profile of the snowpack is how we gain information about its structure. Utilizing various techniques, we gain additional information about shear quality, fracture character, and likelihood of propagation.

Identifying and testing weak layers is a tangible activity seeking direct evidence in a field of inquiry plagued with uncertainty. A snow profile is a point observation in a spatially and temporally dynamic medium. It would be a valuable improvement to be able to sample more sites and gain more information in the same time required for one manual profile.

The concept of probing the snow to gather information about its hidden stratigraphy is not new. In 1936, Seligman described a sounding practice he said was "strongly urged" in Zadarsky's1929 Beitäge zur Lawinekunde. The rammsonde was also introduced in 1936 (Häfeli,1954). Since the rammsonde, several attempts have been made to create an automated or semi-automated sonde to measure and record snow structure properties. All these snow sondes have been successful in generating at least a rudimentary depiction of the snow structure based on the property that they measure. In general, they have provided a representation that incorporates the element of a line to portray the snow structure in a manner similar to the hand hardness outline in a graphical snow profile.

Layer boundaries and thicknesses can be accurate to 1 mm in a manually dug snow profile using visual and tactile techniques in association with a ruled reference. Other than the Rammsonde and the SnowMicroPen (SMP, a penetrometer with a 5 mm diameter conical tip that is motor driven through the snowpack between 6 and 20 mm/sec and the force signal measured every 0.004 mm), none of the snow sonde technology has been able to successfully and consistently place the measured snowpack property against the surface or ground reference as accurately as manual techniques.

A good place to look for the important information gained from snow profiles is to review the history of the tests we have come to use. A progression towards relevant direct evidence can be interpreted from initial use of a shovel shear test, doing rutschblocks, then adopting the compression or stuffblock test, observing shear quality or fracture character, and adding propagation saw test or extended column test to our investigations. The resolution of the layer thickness and location for the current state of practice is as high and accurate as need for use in avalanche hazard evaluation.

What can high resolution snow stratigraphy tell us that is direct evidence or data class I? Schweizer and Reuter (2015) provide us the most current understanding of this. They considered a stability index generated from SMP-derived information in relation to concurrent compression test observations and concluded the relationship of the index to slope stability was poor. They attributed this to the index's lack of consideration of propagation.

In Part III examples of data collected this season with high resolution probes will be presented. Part 1 can be found in TAR 33.2.

References:

Häfeli, R., 1954. Snow mechanics with references to soil mechanics. In: Der Schnee und Seine Metamorphose. H. Bader, R. Haefeli, E. Bucher, J. Neher, O. Eckel, C. Thams and P. Niggli (Eds), Beitrage zur Geologie der Schweiz, Bern, 59-218.

Schweizer, J. and Reuter, B., 2015. A new index combining weak layer and slab properties for snow instability prediction. Natural Hazards and Earth System Sciences, vol 15, 109-118.

Steve Conger is a TAR Editor Emeritus, AAA and CAA Professional Member who continues to enjoy working with uncertainty. Steve's initial avalanche encounter was the first day of summer 1974 and he has accumulated 29 seasons thus far in a broad spectrum of roles including researcher,consultant, instructor, forecaster, control technician, author, rescuer, and dog handler. He resides in Golden BC. ⁂

metamorphism

We are Merik.

By Lee Watson


Merik makes an avalanche.

At this season's patrol refresher for the ski areas of southwest Montana I was asked to be the start-off speaker and recap what I learned at ISSW in Banff. I was a little daunted by the task as I had never spoken in front of such a large audience of my coworkers. But as I worked on my presentation, a theme began to emerge and I didn't think of it as a presentation to my coworkers anymore but a conversation with my friends. It was just what so many of my friends had done for years before me. It was what Merik Morgan had done just a few years before at this very same event as he helped open my mind to some new ideas in snow science that his passion and excitement made him want to share with us. Now it was my time to emulate Merik.

As my instructions were to make people want to go to the next ISSW in Breckenridge in 2016, I realized that some of the audience might need a clarification of "What is ISSW?" So I began with the idea of "*A Merging of Theory and Practice*" and what does that look like? I wanted to begin with a common thread that many of the patrollers from the different ski areas would relate to and I thought again of Merik Morgan. He had been a mentor to so many of us throughout the region that I knew he was one that tied us together. He was Merik.

As we set up for the presentations and the room began to fill I was looking for Merik as I had not seen him in a while and was anxious to see his reaction to my presentation. I was disappointed to find out that due to some personal issues, he was no longer patrolling and would not be there. This one would be for Merik.

So in my awkward way, I began with an attention -getting statement: "What does *A Merging of Theory and Practice* look like? And I answered: "Well it looks like Merik Morgan!" I went on to discuss how many of us throughout the region had been mentored by Merik on avalanche routes and seen how his childlike excitement about a new snow theory combined with his intense scientific understanding of it, with an implementation and explanation, gave us each our own personal ISSW experience right there on the mountain. As I looked around the room I saw nods and smiles as Merik's many friends recollected sharing those occasions and I saw that, for this season anyway, a collective understanding that Merik would not be there and we would have to try to fill those shoes. We would have to draw on what we had learned from him.


Eyes sparkling as usual.

I was a little apprehensive to be talking so candidly with all these people about my friend, especially with him noticeably not there. But I brushed that aside as these were his friends too. This was the ski patrol and snow science community and they were Merik.

I also had another part of my ISSW recap that tied into my reason for bringing up Merik as it reminded me of how often I would hear him say "I love you Man." It came from an ISSW talk given by a Canadian guide who had lost a number of friends to the snow over the years. To me it was a message of love and that by definition it is something that must be shared. His experiences told us how important it is that we tell our friends that we love them while we can. Though Merik was not there for my tribute to him, I hope that in the few months between then and Merik's passing, some of my thoughts were passed on. Maybe as we move on we can use Merik's example and tell our friends more often and more directly that we love them. We love you Merik.

A Bridger Bowl ski patroller for the past 21 years, Lee Watson has held a BA in English from Montana State since 1994 but only began using that degree recently to write poetry as required for a Jackson Hole patrol exchange. ❄

Merik Morgan: a remembrance

By Doug Richmond

Merik was the consummate patroller. He learned the fundamental skills of patrolling as a junior patroller during his high school days in New Mexico. His mastery of all aspects of patrolling made him an inspirational mentor for many of us. For me, he was like a brother for the five years I got to work with him at Bridger. His imaginative ideas for innovations led me to the strategy of always asking: "what's the worst thing that can happen?" before embarking. His outside-the-box philosophical musings still echo through my thoughts now and then.

Merik patrolled professionally at Sierra Ski Ranch, Bridger Bowl, Crystal Mountain, Discovery Basin, and Moonlight Basin ski areas…maybe others. He was Assistant Snow Safety Director at Bridger, Patrol Director at Discovery, and Lead Avalanche Forecaster at Moonlight. He is remembered at all of these places by those who benefited from his knowledge and passionate love for his profession and teammates.

At Moonlight, he was an integral part of the patrol for all ten years of its operation and for the transition to Big Sky ownership. He helped develop and implement their complex avalanche mitigation program. His influence on personnel and strategies will continue to help that program into the future.

At Bridger, where he worked nine seasons: 1989-1998, he is remembered as a strong hard-working patroller with energy and insight that helped move the avalanche program forward. Those of us who knew him are better patrollers for it. He, with his good friend and fellow patroller Peter Carse, pioneered several new avalanche mitigation routes, strategies and explosives delivery trams to help that program.

In Peter Carse's words:

Merik and I were close colleagues in the 90s. He started patrolling at Bridger a year or two after I did, and we spent a lot of time crawling around the Ridge dreaming up new locations for zip lines, called "wires," for the avalanche control program. Working together every chance we got, we installed wires at Super Couloir, Tight Squeeze, Madman's, Barker's Bluff, Lower Sampson's, and Hole in the Wall.

We explored the sidecountry to the north, observing wolverine tracks along the ridgeline north of the Ramp, and thus named Wolverine Bowl. I think Merik also suggested the name "Trident" for the narrow treed chutes just south of Dogleg. Other than "Morgan's Horses," there was another Bridger Bowl place-name he was proud of, a tiny spot on A Route just above the apron traverse and just south of Catch-and-Release that he named "Merik's Mistake" because he tipped over once there while doing a ski cut. But the real reason he latched on to the name was around the time of his Great Experiment, when he decided to get us thinking about some of our old policies (hiking the Fingers only with a partner was one of them) by breaking some of those rules out of uniform, then telling us the next day what he had done.

Merik was always bursting with energy, and since I admired him, it motivated me to get a lot more done than I would have if I hadn't known him. Always very capable and smart, he even climbed a multi-pitch grade 5 ice pillar in Hyalite Canyon known as Cleopatra's Needle. Those familiar with the climb can appreciate the significance, especially as it was, I believe, Merik's one-and-only ice climb ever. What I remember and appreciate most about my friendship with Merik was our chairlift conversations that spiraled, improv-style, across tenuous segues of free-association without faltering.

His favorite popular song at the time was "Send Me on My Way" by Rusted Root. Can't say much about the lyrics, but I remember it had a catchy tune and it will always remind me of good times and metaphysical ramblings with M3 in the mountains of SW Montana.

RIP, my friend, thanks for everything.

—Peter Carse

Amen,
Doug Richmond, Director, Bridger Bowl Ski Patrol ❄

This surface hoar was found on String Lake in the Tetons during the January 2014 cold spell. Brian Johnson, Tyler Bergquist and I were on our way to ski the SW Couloir on Moran. There were big feathery SH crystals similar to that one in the photo on the lake in patches a few meters around, mostly 10-15cms. Besides the SH the lake was mostly bare ice. *Photo by Aaron Diamond*

Surface Hoar: thoughts from Doug Chabot

Southwest Montana is a surface hoar factory, and without it Karl Birkeland at the National Avalanche Center wouldn't get any research done. Unfortunately, once formed we are forced to write about it in our advisories for weeks longer than we want to. And really, why is it called surface hoar once it's buried?

Here are some of my thoughts on these small ferns of death:

- As soon as surface hoar gets buried I begin to worry. Most of the time it's initially buried by powder but I have seen fist hardness slabs avalanche, so I test it with an ECT.
- I pay careful attention to ECT scores to see if it's getting stronger over time. Last year, buried surface hoar produced regular ECTP scores for over a month, helping Ian Hoyer get his Master's Degree. (see page 13 of this TAR for Ian's conclusions) This year a similar layer appeared but it quickly stopped propagating. Go figure.
- Surface hoar can be finicky about where it forms and one of the avalanche center's most time consuming jobs is finding out where it does and does not exist. Sometimes there's no rhyme or reason to its distribution.
- Feathers of surface hoar that are centimeters tall do not always create avalanches. Perhaps the snow capping the layer sifts in between the crystals and acts as a brace.
- Thin layers are scarier (<1cm) because they seem to hang in there longer than I think they should. I'm not sure why that is.
- I have seen avalanches break on surface hoar six weeks after burial. Time alone is not an indicator of stability; the snowpack needs to be tested.
- I cheer when inches of SWE quickly load this layer because it will usually avalanche spectacularly. The surface hoar's first time getting walloped always makes me hopeful to see some natural activity.
- With buried surface hoar, whumphing and human triggered avalanches are closely aligned, more than with other weak layers.
- As the slab above the layer increases in depth and weight, surface hoar can sometimes get more stable as the feathers get pushed into the slab above. (also called "layer thinning")
- Surface hoar is well known to avalanche in lower angled terrain and I treat it with utmost respect and a bit of fear. The only way to deal with it is to dig and test. There's no shortcut.
- In many cases surface hoar shows up as a stripe in the pit wall which takes the guess work out of its location. This helps me explain how and where to find it to the public, both in the advisories and in videos.
- As soon as surface hoar is buried you have at least 4 but sometimes all 5 of McCammon's lemons; bad juju.
- Some people call a buried surface hoar problem a persistent slab or persistent deep slab while others focus on the lemons. For me the term "buried surface hoar" is all it takes to have me sit up straight and pay attention.

Surface hoar avalanches on SE Bowl of Mt. Elly, Teton Pass, Wyoming. Went on storm snow on the drought surface crust with SH from 2/1 and before with the warm windy slab of 2/2 and 2/3 on top of it. *Photos by Garrett Seal*

Doug, director of the Gallatin National Forest Avalanche Center (GNFAC) in Bozeman, Montana, received his B.A. in Outdoor Education from Prescott College in 1986. Since 1995 Doug has worked for the GNFAC as an avalanche specialist. He's also a mountain guide and climber. Doug has been on numerous climbing expeditions to Alaska, Nepal, India, Afghanistan, Tajikistan and Pakistan, resulting in many first ascents and new routes. ❄

After a 3 week dry spell interrupted by only a few days of light snowfall and cloud cover, we came across several areas around Turnagain Pass growing big surface hoar. The predominant grain type formed during this spell was facets, which we tiptoed over for weeks, until they were obliterated by rain. However, we stumbled upon this meadow around 1,600' after some fun facet skiing up high on Tincan. Several mounds in the meadow had feathers averaging around 6 cm, not mm. The biggest we could find were 8 cm. *Photo by John Fitzgerald*

Surface Hoar: thoughts from Bruce Jamieson

1. To stabilize, buried surface hoar requires both load and time. around 10 Feb 1993 a prominent layer was buried in the South Columbias, Soon there was ~60 cm on it. Naturals and then human triggered avalanches. Then it snowed a bit, settled a bit, snowed a bit and settled a bit. By the end of April there was a stiff slab about 65 cm thick on the surface hoar layer. It was still touchy! Classic case of ample time but not enough load.

2. Even when a layer of "old" surface hoar is deeply buried in most places, triggering from thin spots scares the crap out of me. I recall times when the layer is buried a meter or more in most places - seemingly too deep to trigger. Even then, I like to avoid areas where the wind has made slab thickness highly variable over terrain.

TAR:
Have you been using the PST on buried surface hoar? Thoughts on its effectiveness in tracking loss of propagation propensity?

BRUCE:
Regarding the PST: we tend to track major layers of surface hoar - many of which are buried in early to mid February - so long as most of the slab is dry, typically until late March. So we are testing these February layers until they have been buried five to six weeks. For most of these major SH layers, the PST continues to show propagation propensity, although avalanches on these layers are rare in late March. I think the PST is correct about the propagation propensity, and that these February layers are too deep to trigger in most places in the Columbias.

We also see layers of smaller surface hoar crystals that get compressed to ~1 mm by mid March or earlier. We have not studied these layers as thoroughly. However, I don't recall any avalanches on these layers after it gets difficult to drag the saw through these layers.

At fracture line profiles at large avalanches that released on surface hoar layers, the PST consistently indicates propagation is likely if there is propagation to the end of the column, and the cut length is less than 60% of the column length. In Dave Gauthier's original calibration of the PST, a cut length of < 50% (and propagation to the end of the column) was a good indication of propagation propensity. When Mike Conlan and others made PST tests at deep slab avalanche two to three days after they released, 60% was a better threshold. We are unsure if this is due to the depth or due to the tests being done two to three days after the avalanche.

Surface hoar the size of a Dorito.
Photo by John Fitzgerald

A natural slide on surface hoar on a 32 deg slope.
Photo by Bruce Jamieson

Bruce is enjoying work as a consultant, trainer and half-time academic. Bruce is rather fond of ski touring when the surface hoar is on the surface. ❄

Continued on next page ➡

snow science

SURFACE HOAR: Mind-Set and Forecasting Considerations

By Bill Anderson

DEVELOPING THE APPROPRIATE MIND-SET: PATIENCE AND HUMILITY

The important thing to remember here is that I am just a practitioner when it comes to snow. So when you ask my thoughts on surface hoar a couple of things come to mind. Plan B, Plan B, and Plan B. If the mountain landscape offers a forum for learning humility and patience, the surface hoar issue in the snowpack adds yet another wing to the venue. Once again repeat, "patience and humility." If I'm teaching a class on snow, the presence of that thin gray line in the pit wall means a "no go" decision in the moment and more often than not remains that way even after we do all the fancy tests.

So how does a professional translate that mind-set into practice? Well for me it becomes acquiescence to the fact that my end game is that of not knowing -especially on the mountain scale. With the surface hoar issue, the more resolve that I feel that I have my mind wrapped around the problem the more I press myself back to the "patience and humility" mantra.

HONING A STRATEGY: IDENTIFY AND AVOID

Now that I have my mental and emotional state under control, it's time to think about how this weak layer might behave. What stands out is the likelihood that I am dealing with a remarkably spatially consistent layer that might have evolved in very short order. Once buried, this continuity has to be assumed and it affects the patterns of travels in unique ways.

My typical way of dealing with a given slope would be to identify my issues and go around them. Let's consider a slope with wind loading coupled with wind hardening of the top layer. With wind slabs the distribution of the slab and weak layer interface is fairly straightforward and once again the simple solution is just go around it -its structural makeup is quite localized.

With surface hoar as the weak layer, my ability to judge the extent of the problem is limited because there are no surface clues available. Keeping with my wind-affected example from above, let's say that the terrain allows me to ski around the wind loaded zone and then onto the slope, where the slab is much thinner. This shallow slab area is the trigger-friendly zone. After I enter, both the trigger and myself are unfortunately located well downslope. Even if I successfully ski through the pitch, I'm left watching each successive skier come down to my location. It becomes a game of wondering... I'm almost guaranteed that in this scenario someone will fall, giving me the angst of observing them fumble around trying to find their lost ski, all the while asking myself "...when will their boot penetrate to just the right spot, expand some crack out to critical length and bring the slope down?"

THE LAYER OF CONCERN EVOLVES

Abstinence is all fine and dandy on day one, but what about day 10 and 14? For me the answer will involve watching and shoveling. Dig and cut. I'm fully on board with not being on slope for this process, just enough slope angle to make the digging easy. Remember this layer should be spatially consistent so no need to get into higher angle terrain even though you might eliminate the problem for that one slope (by triggering it).

CONTINUITY OF THE WEAK LAYER

Here's a point to consider: This surface hoar layer grew on and throughout all of those old ski tracks that were on slope. Skier traffic means nothing at this point. You have a collapsible weakness that goes across everything. Fracture, once initiated will happily go down and back up the sides of that old ski track if the surface hoar is intact. To be fair however, if the ski track disrupts the continuity of the surface hoar layer it may in fact provide a feature for arresting the fracture process. I keep the fracture model in my mind at this point and the model requires subsidence (collapse resulting in volume loss) of that weakness. So a slope that was skied and subsequently covered in surface hoar will behave differently than a slope that was covered in surface hoar and then skied. Once these two slopes are then covered in storm snow, It's all about the continuity of that weakness. An example is found in the lore surrounding sidecountry sking: at the guides meeting we commonly talk about how we don't have the same surface hoar issue in our terrain that the rest of the range has -that somehow we are in a sort of "safety bubble." What we really mean to say is that the same process that produces out of bounds moguls tends to break the continuity of the surface hoar layer before it gets buried. We just don't see that many surface hoar events in our sidecountry terrain. It may be possible to trigger a surface hoar related slide, but only in the very few places that don't see traffic, but we tend to forget those events.

VISUALIZING THE MOSAIC

So now the plot thickens. In the above scenario, I pose that skier traffic might be able to prevent a surface hoar layer from becoming a problem by severing its continuity. With current discussions of skier impact on snow stability it seemed like an interesting segue into the element of spatial variability with regards to surface hoar. This contrasts my initial idea that I'm dealing with a spatially uniform weakness. The reason for the contrast is that I started with the likelihood that surface hoar is continuous based on how it forms. Once formed it is still subject to change. Perhaps a given aspect/elevation gets enough sun to destroy it, or maybe the winds blow it down. Maybe some of the lee start zones sloughed their surface hoar out at the start of the storm cycle and cleaned out areas that the wind or sun couldn't. Many of the direct action events go unseen and by their nature change how the overall landscape looks. So now the landscape of the snow surface has transformed into a mosaic of different structures with only parts of the landscape having a buried surface hoar component and only a subset of that will be in start zones.

NOW WHAT? THE WAITING GAME

Terrain selection habits are the only defense. It's a matter of being mindful. Some areas in terrain such as the elevation of typical fog lines just aren't worth the effort to assess, so I just write them off at some point in the season if need be. In a pinch there is the possibility of skiing bed surfaces as long as the terrain complexity is simple enough. Skiing defensively as I emerge from the forest into steep open areas is another good habit as surface hoar grows better in clear areas. I just accept once again that I don't really know the true extent of the problem. It is simply PWL-based navigation process and patience.

DIGGING PROTOCOL

In my snowpit I've got the thin, gray lines of surface hoar on the sidewall. In digging, I always keep one sidewall intact. First I tap out an Extended Column (ECT), which is the best way to sniff out fracture possibilities (not that the gray line in your pit wall isn't a clue). Remember to tap on the thinner side of the slab if it varies in thickness across the column. A convenient element of the ECT is digging up slope, thus creating more sidewall. I count and record the number of taps to fracture, but the count receives little or no weight in final analysis. ECTP 28 to me just means I'm on the thick part of the slab, and my biggest concern is that it may well require fewer taps on the side margin where the slab is thin. I consider tap counting decisions to be a relic process from the days of the CT test. The CT test is great for finding layers in the snowpack, but tells you little about fracture possibilities. Fracture characteristic classifications or Q values speak to the post de-lamination friction properties between the slab and bed surface, but not fracture itself. If I see propagation, I have demonstrated fracture, therefore propagation means a definitive no go. There may be rare exception to this, but I can't think of it. I can talk all I want about how these beam-type tests make a two-dimensional process linear or how the tests aren't definitive at moderate hazard...for me the decision has been made and the 20 people behind me can have the run -we all make our own calls. Still, this process of fracture is interesting.

I've saved an intact sidewall of my pit for phase two of the test pit. Once again, what I am looking to do is demonstrate fracture. With this in mind I set up a Propagation Saw Test (PST) with its ends cut slope normal (perpendicular to the surface) and a minimum length of 150cm. The reasoning behind this process relates to the movement arm being created over the saw cut. As I consider the beam (slab) being created by the notch (saw cut), I will eventually need to understand the bending properties and elastic limits (think slab fracture) of this potentially complex laminate (slab) beam. This understanding will be much easier if my historical baseline tests include a rectangular beam. Shape and process aside, the end game here is that over time the cut lengths grow. Anecdotally, it seems like the ECT becomes nonreactive just a little sooner than the cut lengths of PST get to about 50%+ of the length of the beam, which is the time I start to feel better about stability. The other "feature" of the PST is that it makes the waiting game with surface hoar a little easier for being able to monitor progress.

ONE FINAL NOTE

With both of these tests I am only monitoring the possibility of fracture within the snow structure. I'm not ever going to get a definitive "yes" to stability. Pit tests need to be incorporated into the broad scope of all of the snowpack observations; especially in light of variable distribution of the weak layer, these results have to be taken in context.

In the end, if I have surface hoar as my problem it's one Plan B after another and a great time to practice patience and the art of pit digging.

Bill Anderson can be found working in and around Jackson, Wyoming. An exceptionally efficient digger of holes in the snow, Bill occasionally looks like a skier. On any given day in the winter he is probably boring his partner Jill with endless iterations of pseudo scientific snowpack musings. He occupies a spot on many of the guide rosters in the Jackson area and is also certified by the AMGA and an IFMGA member. ❄

How Much Can You Trust an ECT?

By Ian Hoyer

There is a substantial body of research over the last 30 years examining spatial variability of snow stability on the slope scale. However, until recently, all of this work focused on measurements related to fracture initiation such as Rutschblock Tests, Compression Tests, and Stuffblock Tests (Schweizer et al., 2008). In the last several years, some preliminary work has been done examining spatial variability of the Extended Column Test (ECT) (Hendrikx and Birkeland, 2008; Hendrikx et al., 2009; Simenhois and Birkeland, 2009).

The ECT has been shown to be a good measure of slope stability and has become an increasingly popular stability test among avalanche practitioners in recent years. For many of us the ECT has become the standard stability test. This makes understanding the stability variability and reliability of the ECT important.

Methods

Data was collected at 13 study sites across southwestern Montana. Basically, we looked for slopes where we would expect the smallest variability in stability test results. Towards this end, we chose sites that appeared to have consistent snow stratigraphy. Each site was located below treeline in a topographically uniform, planar, wind sheltered clearing with snowpacks relatively undisturbed by skiers or snowmobiles. Twenty eight ECTs were spaced across each slope in a standardized layout with a 30 m x 30 m extent.

Results/Discussion

In total we sampled 23 grids, at 13 sites, with each grid containing 28 ECTs, for a total of 644 tests. Four of these grids had surface hoar as the weak layer, 13 had near-surface facets, one was on depth hoar, and five were on interfaces within new snow.

The percentage of ECTs propagating on a slope was calculated as a measure of the variability across a slope *(Fig. 1)*. There is a wide range of propagation percentage across the 23 sampled grids. Grids with closer to 100% ECTP or 100% ECTN indicate lower variability. Grids with 50% ECTP/ECTN have the greatest variability. Eleven out of 23 grids have greater than 10% of ECT results that are unrepresentative of the slope as a whole. This shows the potential for variability, while also showing that often times ECT results are homogeneous across a slope, with more than half of the grids having greater than 90% agreement in ECT results.

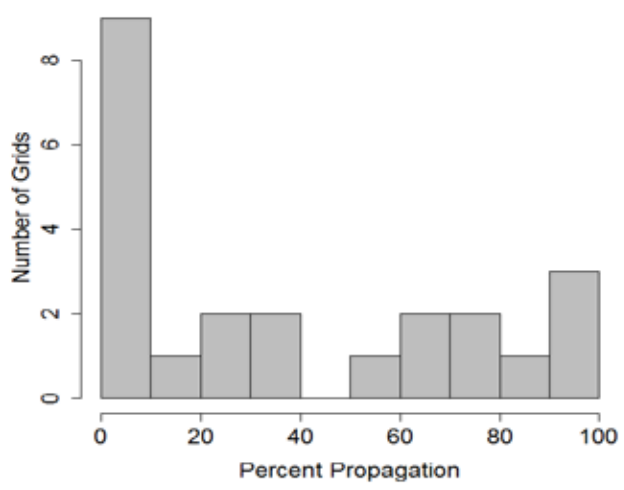


Figure 1. Distribution of propagation percentage for our 23 grids.

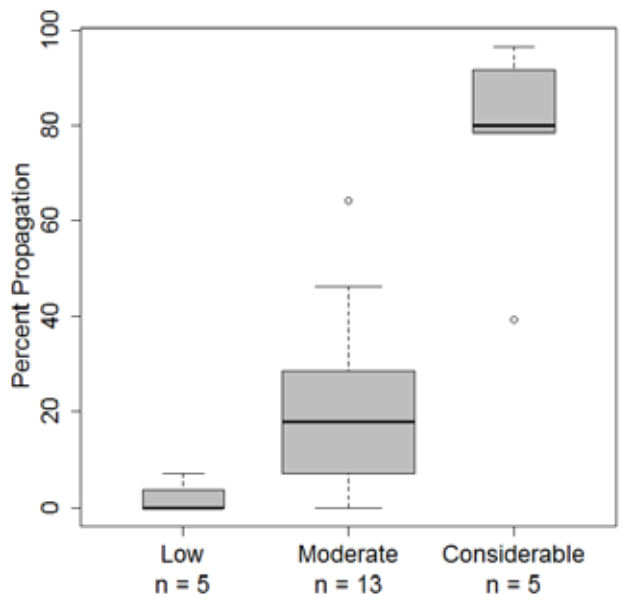


Figure 2. Boxplot of the propagation percentage by the regional forecasted danger rating.

Twenty out of 23 slopes showed indications of some sort of spatial patterns. This includes both slopes that have low/no variability as well as slopes that have clustering of test results. While there are some conditions under which ECT propagation results do not show significant clustering, there is also often clustering, under a wide range of conditions. These results reinforce the recommendations of earlier work (Birkeland et al., 2010; Schweizer et al., 2008) to conduct stability tests further apart to minimize the likelihood of two false stable results.

On four slopes there was a significant relationship between slab thickness and where propagation is most likely on a slope. On each of these slopes, ECTPs were more likely in areas with thicker slabs. In this dataset, performing ECTs where the slab is thickest on a slope will give the greatest likelihood of an ECTP result. However, it is important to remember that these slopes were intentionally picked for their homogenous snowpacks, the slab thickness differences were only up to 20 cm. While this result may not apply across a wider range of slopes, it does show how snowpack structure variability can drive ECT variability.

A clear relationship was found between the forecasted regional danger rating and the percentage of ECTs propagating in a grid *(Fig. 2)*. The higher the forecasted regional avalanche danger, the higher percent of ECTs that propagated. Our results show the most variability when the regional forecasted danger is Moderate. When the regional avalanche danger is either Considerable or Low, results are more consistent. This identifies a major challenge of using the ECT for hazard assessment during a periods of moderate danger. Under Low or High forecasted danger, slope scale stability is generally easier to determine from other snow and weather data. Moderate danger conditions are where a definitive stability test result would be the most useful in correctly characterizing the hazard on a slope, and this is where the ECT shows the most variability.

Conclusions

As a whole, this study demonstrates the importance of carefully selecting sampling locations when assessing stability, and also reinforces the importance of not basing a stability assessment on a single test result. Our results reinforce the advice given by Birkeland and Chabot (2006) to perform multiple stability tests to reduce the probability of false-stable results. Observers must always be looking for instability and place a much higher weight on an unstable test result.

Like all other stability tests, ECTs should be interpreted with an appropriate level of caution and in a holistic fashion considering all other relevant variables. The spatial variability of this test has the potential to be high on some slopes under some conditions, while on other slopes test results will be entirely in agreement.

References

Birkeland, K. W., Chabot, D. (2006). Minimizing "false-stable" stability test results: Why digging more snowpits is a good idea. Proceedings of the 2006 International Snow Science Workshop, Telluride, Colorado, 498–504.

Birkeland, K. W., Hendrikx, J., Clark, M. P. (2010). Instruments and methods - On optimal stability-test spacing for assessing snow avalanche conditions. Journal of Glaciology, 56(199), 795–804.

Hendrikx, J., Birkeland, K. W. (2008). Slope scale spatial variability across time and space: comparison of results from two different snow climates. Proceedings of the 2008 International Snow Science Workshop, Whistler, BC, 155–162 .

Hendrikx, J., Birkeland, K. W., Clark, M. P. (2009). Assessing changes in the spatial variability of the snowpack fracture propagation propensity over time. Cold Regions Science and Technology, 56(2-3), 152–160.

Schweizer, J., Kronholm, K., Jamieson, B., Birkeland, K. W. (2008). Review of spatial variability of snowpack properties and its importance for avalanche formation. Cold Regions Science and Technology, 51(2-3), 253–272.

Simenhois, R., Birkeland, K. W. (2009). The Extended Column Test: Test effectiveness, spatial variability, and comparison with the Propagation Saw Test. Cold Regions Science and Technology, 59(2-3), 210–216.

This work was partially funded by a AAA Graduate Research Grant. *Ian recently completed his M.S. in Snow Science from Montana State University. He now is working as a backcountry avalanche forecaster for the Colorado Avalanche Information Center based out of Leadville, CO.* ❄

snow science

Remote Sensing of Snow Avalanches

Potential and Limitation for Operational Use

By Markus Eckerstorfer, Yves Bühler

Motivation

Throughout the history of avalanche science, the fundamental questions we are trying to solve have not changed much. However, the methods we use to approach the complex processes involved in avalanche release are evolving. Field-based approaches are still the backbone of our research, but we fail in creating both temporal and spatially continuous datasets on avalanche activity.

The use of remote sensing instruments in avalanche science has large potential to help fill these data gaps. Remote sensing is the science of acquiring information about a natural phenomenon without being in direct contact with it. It is a powerful observation tool, as it allows for comprehensive, unbiased, and safe monitoring, temporarily consistent and continuous over large areas. While remote sensing of snow has a long history, remote sensing of avalanches is still in its adolescence phase.

In this paper we review recent advances in remote avalanche detection, list potentials and limitations and make recommendations on how remote sensing might be used in future operational forecasting.

User identification, current needs, and information gaps

In a recent feasibility study (Improved Alpine Avalanche Forecast Service), led by SLF (Bühler et al 2014a), interviews with avalanche professionals were conducted in order to identify potential user groups of remote sensing data as well as information gaps that could be filled.

Three main user groups were identified, being (1) national and regional avalanche warning services, (2) alpine services (avalanche commissions, road administrations, construction companies etc.), (3) the general public (tourists, backcountry users etc.).

The three main information gaps identified were (a) avalanche activity, (b) snow surface information, and (c) snowpack stability. The most critical information gap is avalanche activity information. The data should be quickly available, highly reliable, have a high temporal resolution (less than three days), and a spatial resolution better than five m. Information on avalanche activity and non-activity in particular during bad weather conditions and during nighttime is not available today but would be of major benefit for avalanche warning.

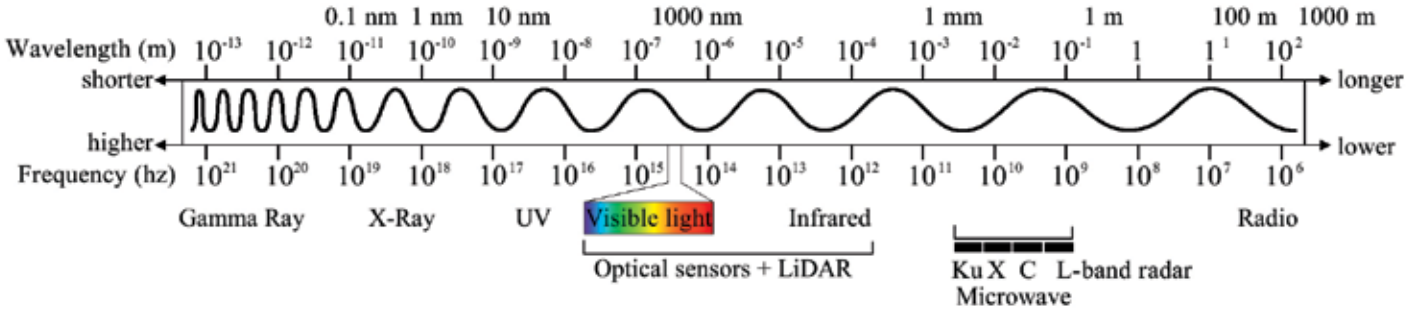


Figure 1: The electromagnetic spectrum. Optical sensors cover the visible light range and parts of the infrared region. LiDAR sensors use the NIR region. Radar sensors cover the microwave region of the spectrum. Figure by Eckerstorfer, modified from different sources.

> Remote sensing is the science of acquiring information about a natural phenomenon without being in direct contact with it.

The electromagnetic spectrum

Remote sensing instruments can be based on ground-, air-, or spaceborne platforms, measuring at different wavelengths of the electromagnetic spectrum *(Figure 1)*. Optical sensors make use of the reflected sunlight in the visible, near infrared and shortwave infrared part of the electromagnetic spectrum and are therefore passive. LiDAR (Light Detection and Ranging) and radar (Radio Detection and Ranging) sensors actively emit radiation and measure what is reflected from the earth surface. LiDAR works in the visible and near infrared, radar sensors work in the microwave region of the spectrum, ranging in wavelengths between 1mm – 1m. Radar sensors have the major advantage of acquiring data during bad weather conditions and darkness.

Optical remote sensing of avalanches

Snow has in general high reflectance at visible wavelengths which is largely dependent on snow grain size and liquid water content in the near infrared wavelength (Wiscombe and Warren 1980, Bühler et al 2014b). Avalanche detection in optical imagery works due to contrast differences between rough avalanche debris and surrounding, undisturbed snowpack at the snow surface. By using very high-resolution optical data, automatic detection algorithms can be trained to detect avalanche debris. These algorithms progressively eliminate regions in the images that are not representative of avalanche debris (Bühler et al., 2009; Lato et al., 2012; Bühler et al., 2013). By doing so, avalanche debris can be detected with very high success rates, however, in all cases, auxiliary field data, or input from models was required for validation. The very high spatial resolution of these optical sensors used comes with high acquisition costs, limited temporal resolution, and spatial footprint. Moreover, optical data is not usable during bad weather conditions or in darkness. A more cost friendly optical remote sensing technology is the use of automatic time-lapse cameras. Recent studies have shown their usability in detailed process monitoring of cornice dynamics (van Herwijnen and Fierz, 2014; Vogel et al., 2012) and glide crack dynamics (Hendrikx et al., 2012). Lastly, the use of structure-from-motion (SfM) in creating 3D models from digital camera images on the ground or on UAV's has been introduced to avalanche science. Gauthier et al. (2014) showed how this comparably cheap photogrammetric method could assist in mapping slab fracture lines and calculating avalanche debris volumes *(Figure 2)*.

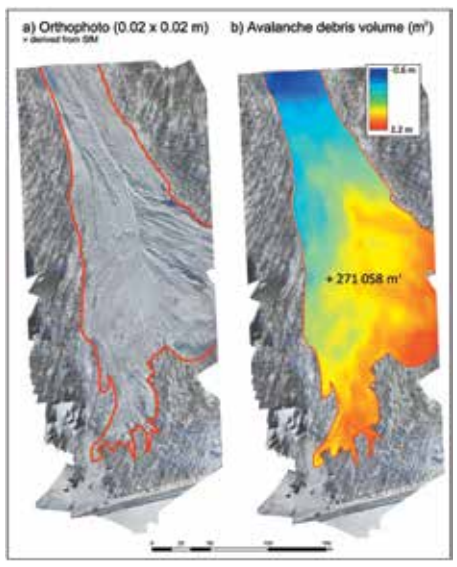


Figure 2: a) SfM generated orthophoto from UAV survey images of an avalanche debris. b) Calculated avalanche debris volume from subtraction of ground surface terrain model and snow surface terrain model. The snow surface terrain model was generated from SfM. Unpublished data provided by Eckerstorfer.

LiDAR remote sensing

Optical wavelength, in which LiDAR operates, penetrates only a few cm into dry snow. Prokop (2008) and later Deems et al. (2014) showed that avalanches can be identified in repeated LiDAR scans as features that show snow mass balance loss in the starting zone and slide path and mass balance gain in the accumulation zone. The expensive LiDAR instruments generate highly accurate surface models (better than 15 cm), with measurement rates of up to 200,000 points per second. This is, to date, the most accurate way to map masses moved by snow avalanche but it can only cover single slopes. However, the fast measurement rates allow for short, energy efficient surveys, making long lasting campaigns feasible.

Radar remote sensing

When a radar signal hits a dry snow surface, it is partly scattered by the snow surface (surface scattering), by the snow grains inside the snowpack (volume scattering) and at the snow-ground interface (ground scattering). Thus, snow volume, liquid water content, snow grain size, snow density, and the presence of ice largely influence the backscatter signal. In wet snow conditions, however, the majority of the radar signal is scattered right at the air-snow surface interface, without any significant penetration into the snowpack. The sum of these radar backscatter contributions is used in detecting avalanche debris. There is currently no quantitative electromagnetic model of avalanche debris scattering published. However, avalanche debris appears as features with increased backscatter in radar

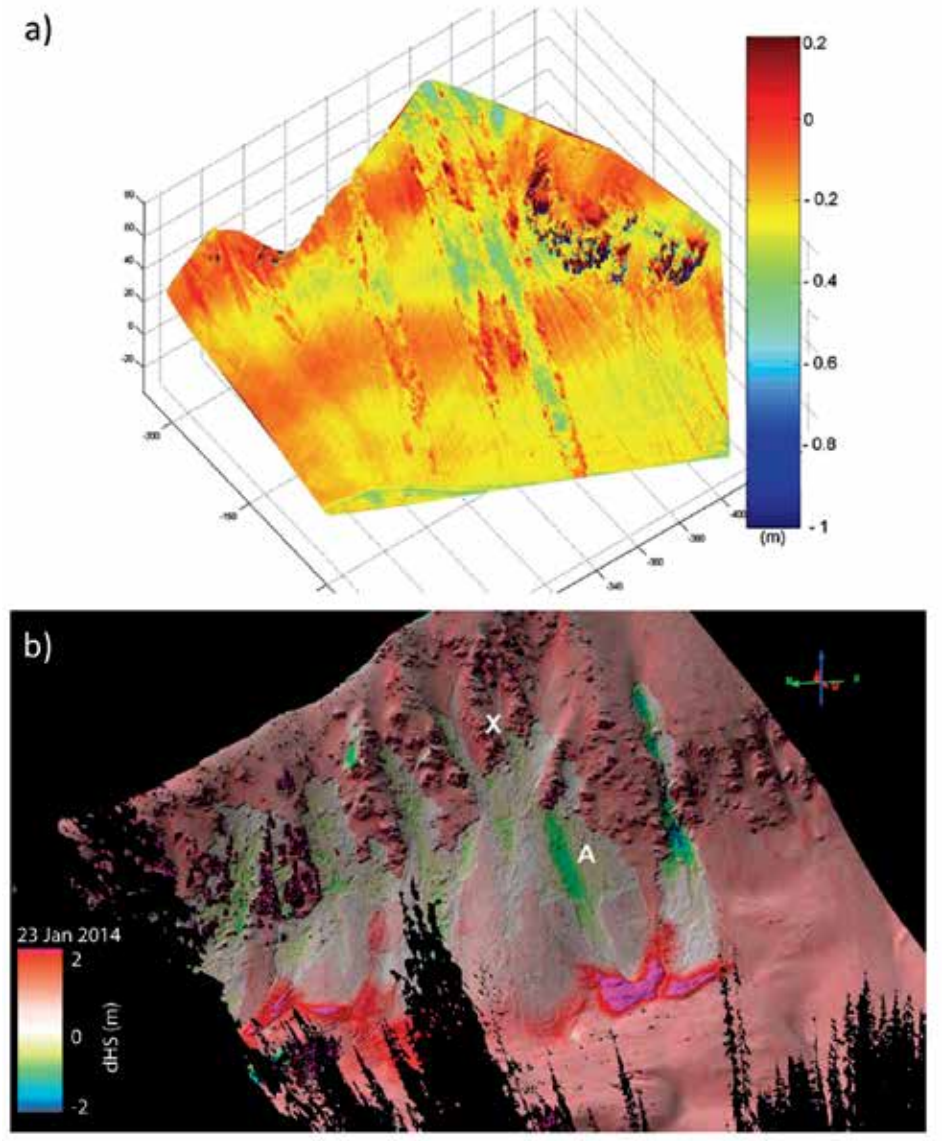


Figure 3: LiDAR detection of snow mass balance gain and loss induced by avalanches. **a)** Figure 8c from Prokop (2008) showing three loose snow avalanches. **b)** Figure 5 from Deems et al. (2014) showing artificially triggered slab avalanches.

images in contrast to the surrounding, undisturbed snowpack. We believe this is due to the sum of increased snow depths, SWE, and surface roughness in avalanche debris.

Recent studies exploring this backscatter contrast find it to be suitable in detecting avalanches, however satellite borne SAR (Synthetic Aperture Radar) data is expensive and temporarily inconsistent in its availability. Still, avalanche debris was either detected in single backscatter images (Eckerstorfer et al., 2014; Malnes et al., 2013) or in change detection images, where the backscatter contrast between images acquired before and after an avalanche was utilized (Bühler et al., 2014b; Wiesmann et al., 2001).

Manual detection of avalanche debris in SAR images is as straight forward as in optical images, with the large advantage that cloudiness or darkness are not limitations. However, the automatisation of avalanche detection in SAR images is to date not as far advanced as in optical imagery.

Ranking of optical, radar and LiDAR sensor platforms

For detecting a single avalanche, spatial resolution of the sensor is the most important factor. Reviewing the existing literature, a minimum spatial resolution of 30 m is needed to detect avalanches. In other words, a detectable avalanche should have at least a debris area of minimum 90 m^2.

In Table 1 we present a ranking of all sensor platforms, divided into optical, LiDAR and radar. This ranking is subjective, done by us as remote sensing experts. Radar sensor platforms score overall the best due to their weather independency and large ground swath of high-resolution data, even though the backscatter signal is not yet fully understood.

LiDAR sensor platforms score second best, due to fast acquisition times and high spatial resolution and accuracy, efficiently operable for example in ski areas. As prerequisite for a successful survey, the slope of interest must be entirely visible from the LiDAR standpoint. The LiDAR has a major advantage in generating snow mass change information by applying a pre- and a post-avalanche scan. However, the spatial range is limited and avalanche gullies in particular are often hidden behind ridges. Airborne LiDAR would solve these issues; however, it is cost intensive and the data processing is time consuming.

Optical sensors score the worst in comparison to the other two platforms. Very high-spatial resolution optical data is expensive and has spare revisit times. Recent studies used airborne optical data, which requires an airplane and expensive sensors systems. Due to the weather dependency, data reliability is not given. However, such very high-resolution optical data is capable of avalanche detection with high accuracy and low false detection rates, and automated detection is already advanced.

Sensor	Acquisition time / revisit time	Spatial resolution	Swath	Costs	Weather independency	Technicality	Avalanche detection	Operationalization	TOTAL
Optical	3	3	2	3	3	2	2	3	21
LiDAR	1	1	3	3	2	3	3	1	17
Radar	2	2	1	1	1	1	1	2	11

Table 1: Ranking of optical, LiDAR and radar sensor platforms based on strength and weaknesses, with "1" being the best score and the lowest total being the best score.

Outline of remote sensing in an operational use

Currently, available operational satellites do not provide near-real time data that would satisfy the different user groups. Several satellite-derived products are capable of detecting and mapping avalanches; however, more research and testing as well as improved operational services are needed. There is considerable hope that the now operational Sentinel-1 satellite will be the future work-horse in SAR detection of avalanches. Sentinel-1 provides free, large ground swath imagery, with short repeat times at high latitudes (3 days). In a recently submitted study, Malnes et al. (submitted), showed that size D2 avalanches were detectable in "change detection images", utilizing the backscatter increase in avalanche debris in comparison to a reference image.

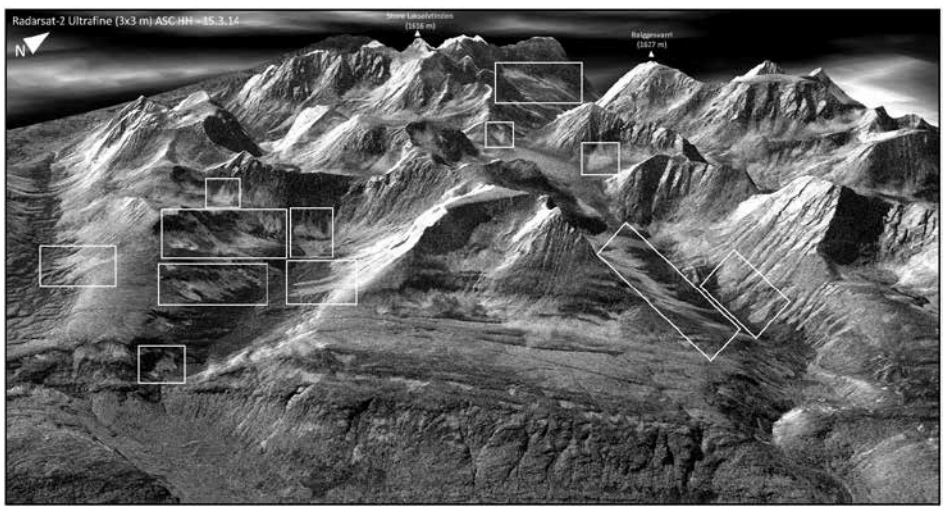


Figure 4: 3D backscatter image from a part of the Lyngen Peninsula in Northern Norway. Avalanche debris (white rectangles) is visible as increased backscatter (light pixels), compared to the surrounding snowpack. Unpublished data provided by Eckerstorfer.

The only operational products that enable real-time detection of avalanches are terrestrial radar with optical platforms such as time-lapse cameras and ground-based LiDAR. Trained users can use such platforms for local monitoring tasks where the target area is small and well known. The instrument can then be installed before winter, allowing for either continuous monitoring or monitoring by need. In addition, UAVs can be deployed, gathering information from recent avalanches, or otherwise inaccessible areas.

Summary

The remote sensing techniques described in this paper are becoming increasingly mature, developing to a point where they can be embraced by avalanche warning services, at least as test products. A critical prerequisite in future applied research is the need to overcome restrictions caused by instrument pricing, data pricing, and data availability. An integrated solution needs to be designed, with the ability to automatically collect and analyze remote sensing data, which is then linked to field observations and modeling outputs. With these developments in place, high temporal resolution remote sensing data will have a great potential to contribute substantially to the improvement of avalanche warning services worldwide.

References

Bühler et al. 2009. CRST
Bühler et al. 2013. Nat. Hazards Earth Syst. Sci
Bühler et al. 2014a. ESA IAP Report
Bühler et al. 2014b. ISSW Proceedings
Bühler et al. 2015. IEEE GRSS
Deems et al. 2014. ISSW Proceedings
Eckerstorfer et al. 2014. ISSW Proceedings
Gauthier et al. 2014. ISSW Proceedings
Hendrikx et al. 2012. ISSW Proceedings
Lato et al. 2012. Nat. Hazards Earth Syst. Sci
Malnes et al. 2013. ISSW Proceedings
Malnes e al. submitted to The Cryosphere
Prokop 2008. CRST
van Herwijnen & Fierz 2014. ISSW Proceedings
Vogel et al. 2012. The Cryosphere
Wiesmann et al. 2001. IGARSS, IEEE Proceedings
Wiscombe & Warren 1980. JAS

Markus "Max" Eckerstorfer

I have a MSc degree in geography and cartography from the University of Vienna. After working a winter at the Tyrolean Avalanche Warning Service, I moved to Svalbard in the Norwegian High Arctic to take a PhD on the snow and avalanche climate of central Svalbard. Since 2013 I have been working at a research company called Norut in Tromsø, Norway, working on the detection of avalanches with satellite borne radar remote sensing. I live in Tromsø with my Norwegian girlfriend.

Yves Bühler

I got my MSc in geography at the University of Zurich, Switzerland. After working as a high-school teacher for two years I started a PhD in remote sensing at RSL, University of Zurich. After completion in 2009 I moved to Davos with my wife and two boys to work for the WSL Institute for Snow and Avalanche Research SLF. I am member of the RAMMS core team and the responsible person for remote sensing related activities at SLF, focusing on mapping and modeling of alpine natural hazards. ⁂

SLIDES: Snapshots & Stories

These are photos of an artificial avalanche made from a snow gun snow on Pandemonium at Purgatory Resort in SW Colorado.

It ran Dec 18, 2014 and had a FL of about 4 feet.

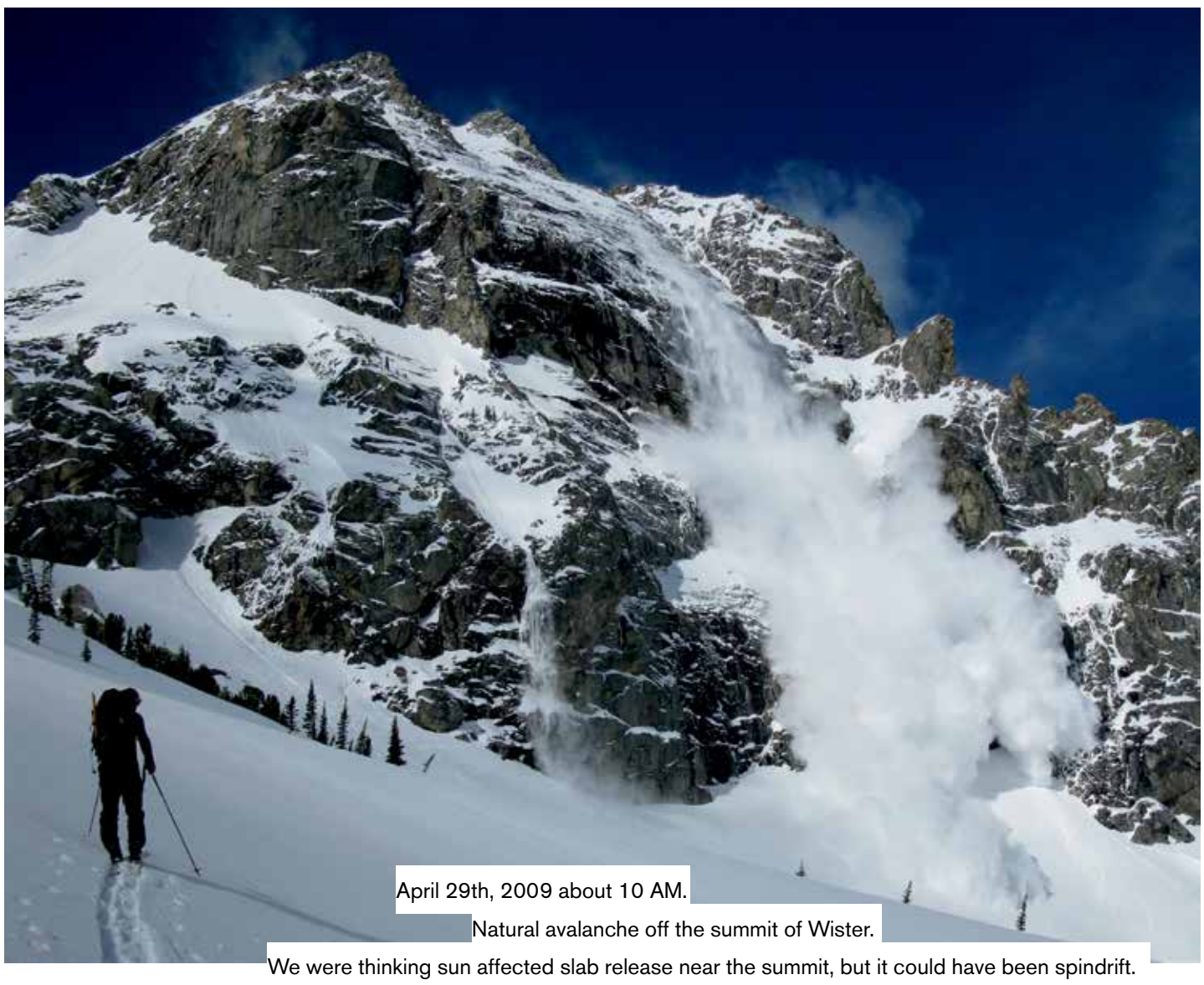
The slab was pencil-hard artificial snow and ran on 4 mm depth hoar.

The snowmaking gun was at the top right of the 36-degree part of the slope and was running for a few days.

As there is no classification for a human-made snow avalanche, I rate this one as HS-AO-R2/D1.5/I *

Trigger was artificial snow from a snow gun. The hard slab debris was especially hard!!

–Andy Gleason



April 29th, 2009 about 10 AM.

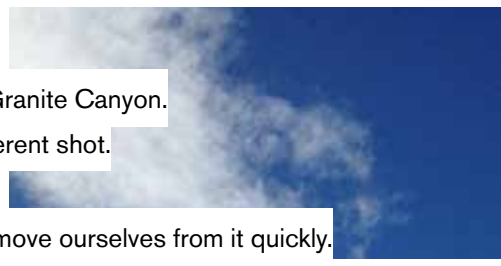
Natural avalanche off the summit of Wister.

We were thinking sun affected slab release near the summit, but it could have been spindrift.

Six inches of new cold storm snow on spring pack. The skiing off the col east of the summit was a top ranker!

–Derek Ellis

This photo was taken of Flower Mount



This photo was taken on Pandora's, head of Granite Canyon.

We did a lap on the arch, and were heading back around for another lap on a different shot.

We ended up below a scary looking slope right above a gnarly terrain trap.

We got ourselves out onto it, then voiced our dislike of the situation and the need to remove ourselves from it quickly.

A couple of minutes after we had passed underneath it, some people behind us started yelling to us about an avalanche, but said ev

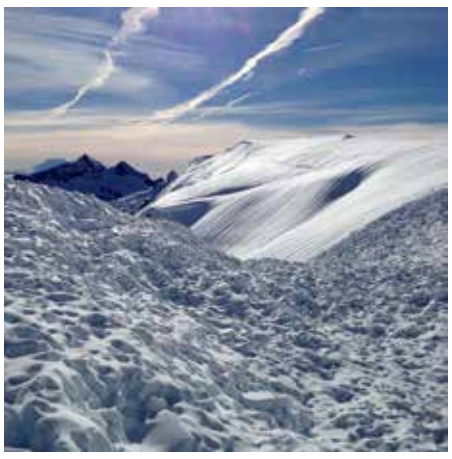
We skied our second line and took a lap back around to check it out, and that is what we found.

The slope that released was warming all day; it was two days post-26 inches in three or four days, if I remember correctly.

When we went up to check out the crown, it was off a little sub-ridge that was wind loading the start zone as well.

Poor terrain selection that day, glad we got the lesson without the consequences.

–Van Roberts



Part of the Northwest Avalanche Center's outreach efforts this year involves submitting photos occasionally to NWAC's Instagram. New this season, we have the IG account able to link to a "film strip" in our daily avalanche forecast discussion. This can be done from the field and gets inserted into the forecast page in real time. Obviously in a normal winter, with our very active and dynamic snowpack, this will be an incredible asset for the community. This season...well, you know how it goes!

–Jeremy Allyn

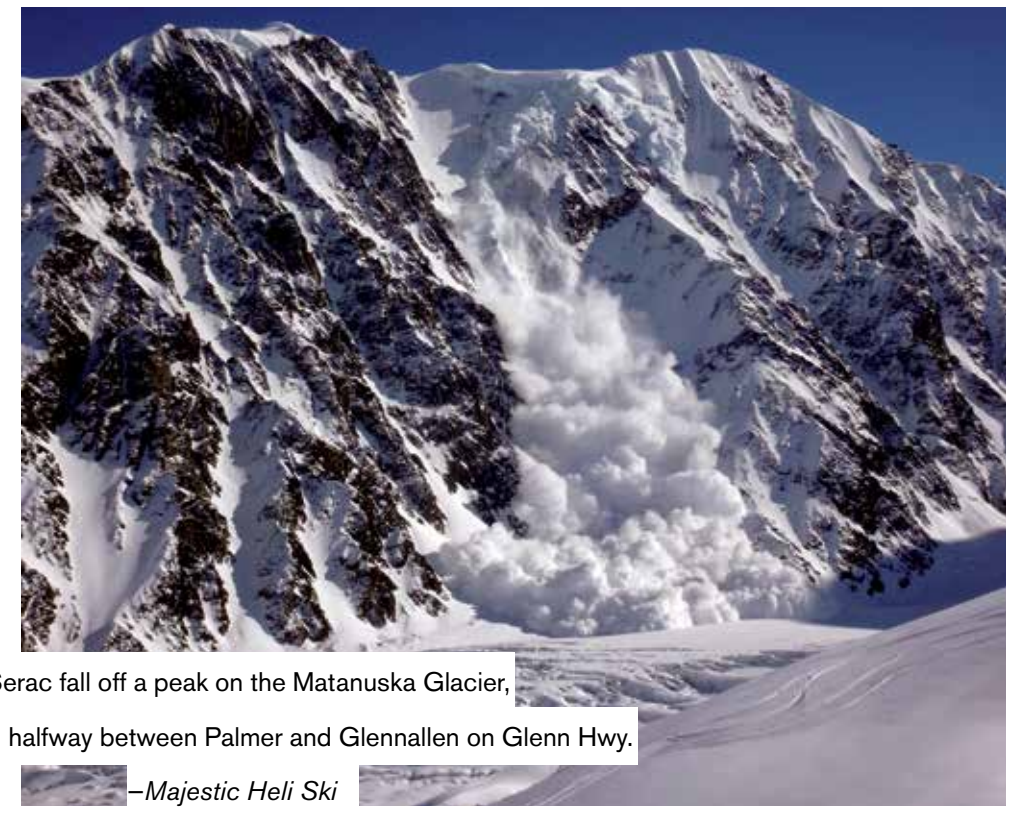
tain near Haines, Alaska on January 29. The avalanches were result of a massive storm cycle from the week before.

You can see on the high slopes an avalanche that caused a secondary, and those very well could have initiated the large one below.

To give you perspective, the crown on the lower mountain is anywhere from 15-20 feet thick and was observed from 10 miles away.

–Alan Gordon, Avalanche Forecaster, Coeur Alaska

veryone was ok.



Serac fall off a peak on the Matanuska Glacier, halfway between Palmer and Glennallen on Glenn Hwy.

–Majestic Heli Ski

STRATEGIC MIND-SETS

By Roger Atkins

Mind-Set: 1. A fixed mental attitude or disposition that predetermines a person's responses to and interpretations of situations 2. An inclination or a habit.

—The American Heritage Dictionary, 2009

I believe we each adopt a mind-set about a day in the mountains, formed mostly from an assessment of risk combined with our desires, but also from peripheral influences we may not acknowledge. Our mind-set is a filter that affects our perception of risk and desire, influencing our emotional response to the mountains; it is the internal context against which decisions are made. Consider entering the mountains after a storm, the sky is clear, the snow is beautiful. The slopes are full of allure, perceived as desirable and friendly places, associated with pleasure. As you approach, a large avalanche is remotely triggered on a slope you intend to ski. In that instant, your perception of the mountains changes. Instead of your desires, you see your fears. Your mind-set has changed your perceptions, and your decisions also change. A mind-set well suited to actual conditions is an influence towards good decisions while a mind-set not synchronized with conditions can lead to poor decisions. Our mind-set becomes strategic when we identify common mind-sets and deliberately adapt our mind-set to the current situation.

RATIONAL THINKING AND INTUITION

Competence depends on unique human capabilities: rational thought based on knowledge, intuition based on experience, and strategies to cope with uncertainty.

School teaches analytic skills, trains us in logic and fills our memory with information. With adequate training and resources, we have calculated our way to the moon. However, most of us require undivided attention and adequate time to perform even a simple analysis. Rational thought is powerful, but it is not everything; overthinking taxes the brain and brings us to a halt.

There's a time to think, and a time to act.
And this, gentlemen, is no time to think.
From The Film "Canadian Bacon" (1995)

Intuition is your brain automatically processing information outside of your awareness and is valuable in many situations. Nonconscious processes operate all the time in complex decision-making; we overrate how much our conscious is in control. "Dual Process Theory" states that we operate on two levels: the conscious (rational, deliberate) and the unconscious (automatic, intuitive). Combining the two is most effective, but both need proper priming.

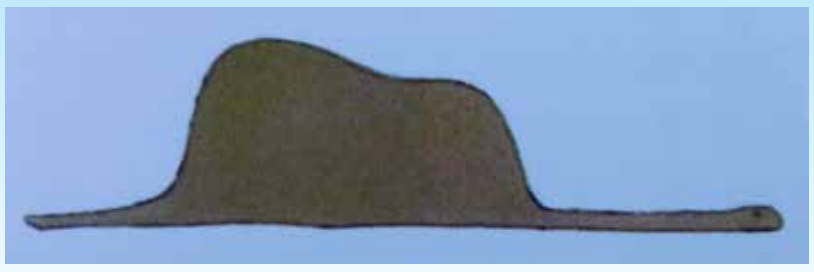
Intuitions can be difficult to explain, they are strong judgments based on emotion evoked by a perception of something external that you may not even be aware you noticed. Intuition is becoming recognized as an unconscious associative process based on fast, sophisticated mental operations. We encounter a situation and rapid automatic pattern recognition based on prior experiences causes us to react without stopping to think. A properly primed intuition associates emotions correctly for the situation, causing us to react appropriately.

Both processes can contribute to good or bad decisions. The rational process fails if the reasoning is based on faulty or uncertain information or assumptions (garbage in, garbage out), if it is too slow (paralysis by analysis), or if it focuses on one problem and does not account for other considerations (tunnel vision). The automatic process fails if a person's mind-set biases the process in directions not well suited to conditions or if a person lacks valid experience to train their automatic responses for the situation.

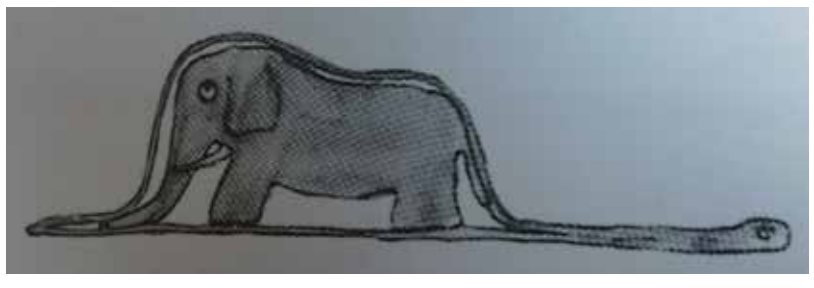
PERCEPTION

From *The Little Prince* by Antoine de Saint-Exupery:

...My Drawing Number One looked like this:



I showed the grown-ups my masterpiece, and I asked them if my drawing scared them. They answered "Why be scared of a hat?" My drawing was not a picture of a hat. It was a picture of a boa constrictor digesting an elephant. Then I drew the inside of the boa constrictor, so the grown-ups could understand. They always need explanations. My drawing Number Two looked like this:



The grown-ups advised me to put away my drawings of boa constrictors, outside or inside, and apply myself instead to geography, history, arithmetic, and grammar...

We are born unable to recognize faces, but we become sophisticated at facial recognition. In a crowd, we identify individual faces of people we have only met once, we identify age and gender from unfamiliar faces and we interpret emotion behind facial expressions. Facial recognition is a pattern recognition skill that happens automatically and almost instantly without conscious effort. Facial recognition skills are not infallible; sometimes we fail to recognize people we know or misinterpret emotion. Context matters, we are more likely to recognize a movie star on the silver screen than in a chance encounter on the street.

We do not see things as they are, we see them as we are.
—Anais Nin

We recognize faces from photographs or even from caricatures. Our interpretation of a face is not the face itself, but is our association of an image we see with someone we know.

Software exists for facial recognition through image analysis. If in doubt, we may also try to analyze features to help recognize a face, but our native automatic abilities far outperform any purely analytical method. Nobody would suggest abandoning automatic facial recognition skills to rely only on image analysis to recognize each other. Like people's faces, we develop pattern recognition skills for the mountains. We read winter mountains like we read people's faces, but what we see in the mountain snows is partly a reflection of ourselves; a projection of our desires and

fears onto the terrain. In the mountains, we should not ignore intuition and make decisions only on rational thought, but we should create mind-sets conducive to appropriate intuitive response. And to aid in developing that body of intuitive response (eg mind-set open to learning, open to the process of examining previous decisions and filing the cause-effect data/ patterns appropriately.)

Emotional responses to our surroundings are not useless. Our perception of circumstance results in an instant and automatic emotional reaction that translates into action: our automatic systems allow us to perceive threats and opportunities and act quickly without analysis.

Although not conscious, our automatic responses are influenced by our mind-set. It is our mind-set that creates our perception of threats and opportunities.

How we perceive the terrain strongly influences decisions – desire vs. risk. In turn, how we perceive the terrain is strongly influenced by our mind-set. The same powder-covered slope may be perceived as threatening or as desirable at different times or by different people. In fact, the slope is threatening at some times and desirable at others. We make better decisions when our mind-set helps us correctly perceive the slope as threatening or desirable.

UNCERTAINTY?

> **...as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know...it is the latter category that tend to be the difficult ones**
>
> *—Donald Rumsfeld*

We know there is quantifiable uncertainty in measurements and assessments. There is also a subjective feeling of uncertainty about the outcome of a course of action. The possibility of "unknown unknowns" adds uncertainty about uncertainty.

> **You cannot be certain about uncertainty.**
> *—Frank Knight, University of Chicago Economist*

We need terrain and snowpack information, but we don't always need to know why we feel the way we do. Rational analysis of objective information reduces uncertainty about the state of the snowpack, but often not enough for clear decisions about specific terrain. Intuition responds well to qualitative information, which is often more useful than quantitative information for reducing uncertainty about choosing a course of action.

Many grey-haired avalanche workers say they felt more certain about their knowledge when they were younger, but experience has taught them to be less certain. However, most also acknowledge becoming more competent decision-makers. Some things about the snowpack and terrain will always be unknowable, but understanding about the things we don't know helps us devise strategies to cope with them. Decisions are often based more on what we don't know than on what we do know.

> **Not everything that can be counted counts, and not everything that counts can be counted.**
>
> *—Albert Einstein (attributed)*

STRATEGY

Strategy is an overall approach to cope with uncertainty: to satisfy our desires and avoid the consequence of risk. Complete strategies combine both rational and automatic behaviors.

Some strategies are rational; we gather and analyze information to reduce our assessment uncertainty, then make conscious decisions based on a subjective probability of the outcome for different options.

Categorizing situations based on patterns carries little uncertainty and yields large returns for knowing how to respond to a particular situation. Automatic responses are not consciously controlled, but can be indirectly influenced by our mind-set. Strategic mind-set is a way to deliberately prime ourselves to automatically respond correctly for the current situation.

Objectives are determined by desires. Desires that are compatible with conditions help us choose suitable objectives for the time. ***Wisdom is largely a matter of selecting desires that are compatible with the conditions.***

Most backcountry guiding operations have continuity in their terrain, which allows different strategies than situations where terrain is visited intermittently or when visiting new terrain. It is easier to adjust decisions from an established base than to start from scratch. Typical mind-sets for backcountry operations are about making adjustments to suit changing conditions while typical mind-sets for approaching new terrain are about choosing a strategy that suits the current conditions. Table 1 shows an example of some typical mind-sets for approaching new terrain under different conditions. Basic strategies are listed, actual strategies become nuanced and more complex with experience.

Roger Atkins has a background in the physical sciences and a passion for powder skiing. This led to a certain negligence at office work, a curiosity about the physics of snow and avalanches, and thirty years as a helicopter ski guide. He remains intrigued with how best to cope with the inherent uncertainties we face when travelling in avalanche terrain. ❄

MIND-SET	TYPICAL CONDITIONS	BASIC STRATEGY
Assessment	There is a high degree of uncertainty about conditions, such as when first encountering the terrain for the season, entering new terrain, following a lengthy period with limited observations, or after substantial weather events.	Select conservative terrain in which to travel confidently while more information is gathered to gain confidence in the hazard assessment. Form perception of What type of avalanches are likely, Where they are likely, How Big they may be and How Easy are they to trigger.
Storm Mind-Set	During and immediately after storms. The Storm Mind-Set varies from High Alert to Caution, depending on hazard assessment.	Avoid start zones and run-outs that may be affected by natural storm slabs.
Persistent Slab Mind-Set	Persistent weak layers are known or suspected. The Persistent Slab Mind-Set varies from High Alert to Caution, depending on hazard assessment.	Use extreme caution during reactive periods; be disciplined and maintain conservative terrain choices even when instability appears unreactive.
Wind Slab Mind-Set	During and immediately after wind events with snow available for transport.	Assess distribution pattern, size, and ease of triggering. Avoid areas with wind slab; consider ski cutting for small slabs.
Normal Caution	Storm instabilities have settled and persistent instabilities are not suspected, but avalanches may be possible to trigger in specific locations.	Use caution when travelling in run-outs and slide paths; assess start zones carefully before entering.
Freeride	The hazard assessment suggests that only small avalanches are possible in very isolated terrain features, and there is a high degree of confidence in the hazard assessment.	Any skiable terrain may be considered with due attention to the possibility of small surface avalanches-use good sluff management on larger features
Spring Diurnal	The hazard assessment suggests that the only substantial hazard is from wet avalanches during the afternoon thaw phase of the diurnal freeze-thaw cycle.	Assess for adequate overnight freeze and avoid avalanche terrain during the thaw phase of the cycle.

Table 1: Strategic Mind-Sets along with typical related conditions and basic strategies.

DECISION-MAKING LIKE A GIRL?

A Look at the Gender Heuristic Trap

By Emma Walker

Heuristic trap: a mismatch, where we base decisions on familiar but inappropriate clues.

—Ian McCammon, 2002 ISSW paper

I spent my college years skiing, climbing, and backpacking in the Colorado Front Range, mostly in the company of men. I didn't yet have a name for what I was experiencing as an outdoorswoman; namely, that I was usually the only woman. More than once, a group of guys turned to me as iconic Rocky Mountain thunderheads approached, asking if we should turn around. Why are you asking me? I always wondered. I wanted to reach the summit as badly as anybody, but I often found myself relegated to the role of Mother Hen.

Years later, thanks in part to Margaret Wheeler's April 2008 TAR piece ("Backcountry Skiing & Gender: The Possibility of a 'Gender Heuristic Trap'"), I finally have a name for what I experienced in my early twenties—which, for the record, were fraught with poor decision-making, both in the back- and frontcountry. My partners, it seems, had fallen victim to the gender heuristic trap.

It was the dearth of women in the backcountry that inspired the question behind my eventual graduate thesis: Why are there so many fewer women in the backcountry? Is it really because we're more conservative?

As it turns out, this is a tricky question to answer. While a great deal of energy has been put into researching the effectiveness of various decision-making tools and the ways avalanche professionals employ them, little attention has been paid to the methods male and female professionals use to gather information and make decisions—specifically, whether they really use different methods. This study sought to understand the influence of an individual's gender identity on their decision-making and risk tolerance.

The hyper-subjective nature of this question necessitated a mixed-methods approach. I was looking for a finite population of professionals whose answers might shed some light on general attitudes in the outdoor community, so, with the permission of Denali concessioners, I surveyed guides working on the mountain during the 2014 season. The survey collected basic demographic information about guides—background, age, experience, certifications, and, of course, gender. The demographics section also contained more subjective questions about respondents' personal and professional risk tolerance levels. The survey asked guides to prioritize a set of ten decision-making factors from most to least important. (The options were derived from an earlier pilot study, and included an optional fill-in-the-blank "other" selection.) Guides then ranked Ian McCammon's FACETS—the acronym American practitioners use to remember the human factors that might otherwise lead to our ruin—in order from most to least challenging to them personally. Finally, respondents were asked to visualize a trusted backcountry partner and answer a set of demographic questions about them.

Of roughly 150 guides working on Denali in 2014, 48 completed the survey. Participants ranged in age from 21 to 57, and 40 of the guides (83%) were male. (This gender breakdown is consistent with NPS user data collected on Denali climbers over the last fifteen years.) Professional experience levels ranged from one season to 25; participants' collected experience totaled 395 seasons. Most guides held a Level 2 avalanche certification (56%) or above (29%). In addition, guides had a wide variety of other certifications, including Wilderness First Responder (83%), an AMGA certification (43%), AAA professional membership (13%), and AIARE instructor training (10%).

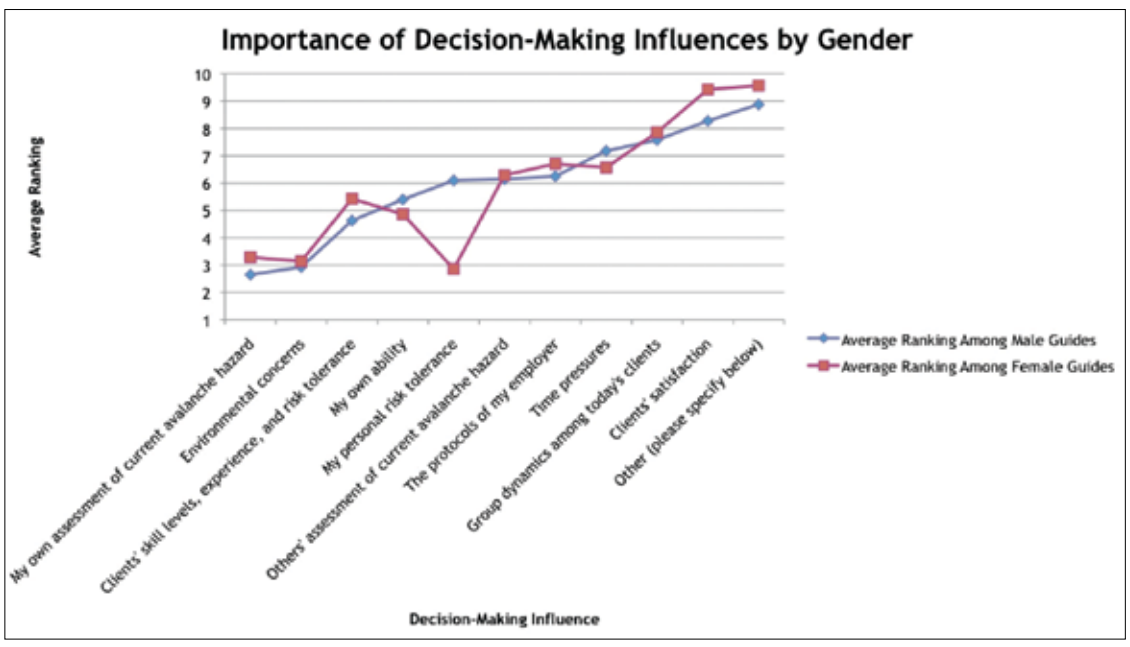


Fig. 1: Guides' rankings of decision-making factors were averaged. Lower numbers mean higher priority (i.e. #1 is the highest possible average).

Overall, guides prioritized the decision-making factors in the following order:

1. My own assessment of current avalanche hazard
2. Environmental concerns
3. Clients' skill levels, experience, and risk tolerance
4. My own ability
5. My personal risk tolerance
6. Others' assessment of current avalanche hazard
7. The protocols of my employer
8. Time pressures
9. Group dynamics among today's clients,
10. Client's satisfaction

These rankings were averaged, both overall and by gender, producing a number between 1 and 10 to describe a factor's importance.

Only two decision-making factors had significantly different rankings: female guides ranked clients' satisfaction lower than male guides, and ranked the importance of their own personal risk tolerance significantly higher than male guides. To better understand the reasons for these differences, I looked for correlations between an individual respondent's ranking and their age, experience, and training. None of these relationships were statistically significant.

Denali guide Leighan Falley on the summit in 2013, after successfully guiding the first Indian woman to reach the Seven Summits. *Photo by Tucker Chenoweth*

Guides also ranked the FACETS, and the same averaging system was used to determine overall and gendered rankings for each factor. Familiarity was by far the highest (it averaged #1.6, and no significant difference existed between genders); it was ranked #1 by 31 of the 48 guides. This trend, which makes sense considering that guides take clients up the same route season after season, is heartening: both male and female guides are aware of this potential flaw in their decision-making process, a step toward avoiding the trap.

Given that few differences existed between male and female responses to questions about decision-making and heuristic trap susceptibility, it was interesting—though not necessarily surprising—that 87% of guides' trusted partners were male. Most guides reported that their partners had more experience (78%), were older (57%), had more training (53%), and similar risk tolerance (66%) relative to the respondent. Of the few female partners cited, all were reported to have similar levels of experience and training to the respondent, but in 50% of cases, were perceived to have lower risk tolerance. The other half was perceived to have similar risk tolerance—never higher.

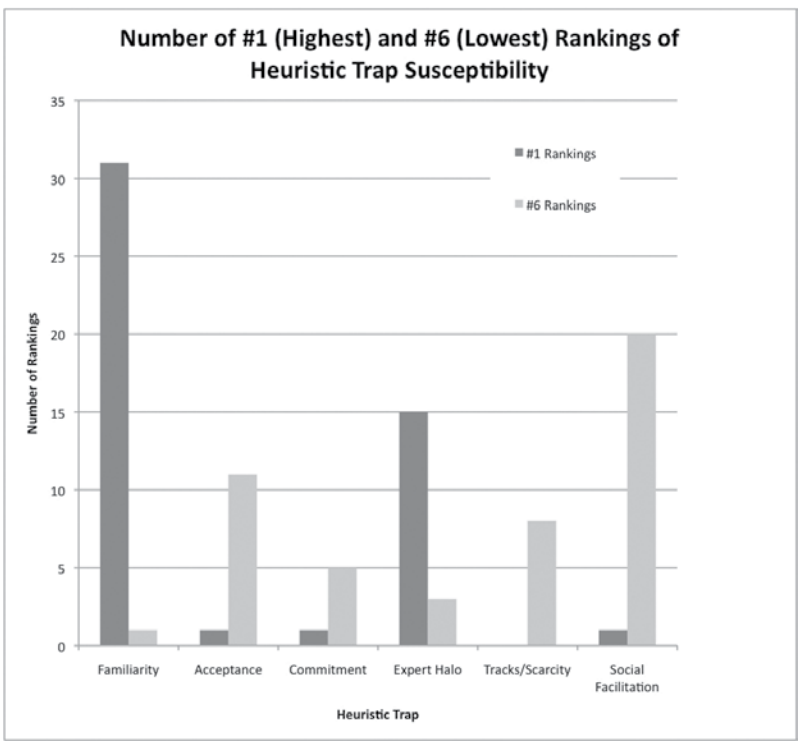


Fig. 2: Number of #1(highest) and #6 (lowest) rankings of heuristic trap susceptibility. Note that Familiarity has both the most #1 and fewest #6 rankings.

Based on these perceptions, I revisited guides' responses to the questions on risk tolerance; no significant differences existed between male and female guides' reporting of their own risk tolerance, either personally or professionally.

In his 2002 ISSW paper, Ian McCammon plainly defines the heuristic trap: a "mismatch, where we base decisions on familiar but inappropriate clues." While there's still plenty of research to be done—this study is by no means a comprehensive look at backcountry gender dynamics—the evidence points to the existence of another potential trap, albeit one that doesn't fit well into our FACETS acronym.

There's no question that individual risk tolerances in the backcountry vary widely, but when we tie a person's risk tolerance to their gender and make decisions based on a partner's (perhaps incorrectly) perceived risk tolerance, we risk falling victim to the gender heuristic trap. Of course, even the most levelheaded among us is affected by complex intra-group dynamics: McCammon's research found that mixed-gender groups expose themselves to greater risk than all-male groups. "Showing off for the girls"—or, as I have do admit I've found myself doing before, upping the ante to fit in and be taken seriously as a woman in an otherwise male group—can lead us to stop paying attention to our systems, and that's when we get into trouble. As practitioners—whether you're a ski patroller, an avalanche educator, a guide, or skiing with friends on your day off—recognizing and acknowledging those preconceived notions about gender, both in ourselves and others, can go a long way toward mitigating this potential trap.

References:

McCammon, I. 2002. Evidence of heuristic traps in recreational avalanche accidents. Proc. Int'l Snow Science Workshop, Pentiction, BC, Oct. 2002, 244-251.

Walker, E. and Latosuo, E. 2014. Decision-making practices in Alaska's dynamic mountain environments: A study of professional mountain guides. Proc. Int'l Snow Science Workshop, Banff, AB, Oct. 2014, 202-209.

Wheeler, M. 2008 Backcountry skiing & gender: The collision of hormones and relationships with decision-making in avalanche terrain or the possibility of a "gender heuristic trap." The Avalanche Review, Vol. 26, No. 4. 12-28.

Emma splits her time between her two favorite mountain ranges, the Chugach and the Colorado Rockies. She recently finished her master's degree in outdoor and environmental education at Alaska Pacific University, and currently works at the Alaska Avalanche School, where her favorite part of the job is doing Know Before You Go programming for local schools. ❄

CONSCIOUS/ UNCONSCIOUS DECISION-MAKING

Know Your Own Competence

By Philip A. Ebert

Competence: the quality of being competent; adequacy; possession of required skill, knowledge, qualification, or capacity.

—*Dictionary.com*

Backcountry skiing requires us to make decisions in an inherently uncertain environment with possibly fatal consequences. However, skills and competences to recognize and avoid the possible dangers in avalanche terrain can help to reduce these dangers and render the residual risk "acceptable." Also, there is a sense in which to be a responsible backcountry enthusiast is to be one who has acquired competences to deal with the relevant dangers. Thus, being a competent decision-maker is not only important to reduce the overall risk involved, but also plays a pivotal role in rendering an engagement in so-called "extreme sports" socially acceptable.[1]

In this context, I want to raise an issue rarely discussed: while being competent is one important aspect for a responsible risk engagement, we should also ask the question what is required to assess whether a decision-maker actually is competent or not. To raise this question is to reflect on what kind of evidence is available to a decision-maker to justifiably believe that he/she really is competent.

Now, this issue should not be put down as "merely academic" or worse "philosophers' musings," but it is important to decision-making more generally. Here is why: let us for simplicity categorize decision-makers into two groups: competent and non-competent. Given that one is either competent or non-competent, a decision-maker might either correctly believe that she is competent, correctly believe that she is non-competent, falsely believe that she is competent, or lastly, falsely believe that she is non-competent. The category that is of most relevance to us is the one in which a decision-maker falsely believes that he/she is competent. Why is this?

Well, first of all, falsely believing that one is competent will lead decision-makers to wrongly think that they can reduce the various risks to an acceptable level, even though they, in fact, lack the relevant skills. Secondly, self-efficacy—the strength of one's belief in ones own abilities—can play an important factor determining risk attitudes. That is, the greater your belief in your own competences in managing the risks, the more willing you might be to take on various risks.[2] If, however, a decision-maker falsely believes himself to be competent, he/she might end up taking on higher risks even though he/she is non-competent—a possibly very dangerous situation. Lastly, there is a phenomenon called the "expert halo": that group decisions in avalanche terrain are often strongly influenced by the person the group takes to be the most competent.[3] If the group chooses the person who portrays her-/himself as being the most competent, yet she/he is wrong about it, then this might endanger not merely the decision-maker who falsely believes to be competent but groups as a whole!

So then what counts as good evidence for being a competent decision maker? In the following, we call this kind of evidence—evidence for being competent—higher-order evidence. Let us start with an extreme—and admittedly ludicrous—case. Imagine someone, let us call him Joker, who believes he has the "competence" to always choose the winning numbers in a lottery. An easy way to show that this belief in the presumed competence is unjustified is to have him play a handful of lotteries and look at the result. We will not require many cases in order to show that Joker suffers from an illusion of competence. On the other extreme, consider the case of a world-class archer, call her Erika. If we had any doubts as to whether her belief that she is a competent archer is justified, we could just look at the results of her exercising this very competence. Again, a handful of "shots" towards a suitably chosen target will suffice to show that she is competent and that she is justified in believing that she is competent.

What these considerations suggest are that we can bootstrap from the results of exercising a competence on a critical number of cases to a justified belief in having this competence (or even lacking it). If this is correct, a similar reasoning should also apply in the case at issue: decision-making in avalanche terrain. Hence, successfully avoiding dangers such as avalanches over many years would then constitute higher-order evidence that one is a competent decision-maker.

Now, I think this kind of reasoning—though intuitive in the case of Joker and Erika—is inappropriate and possibly dangerous when applied to avalanche decision-making and, more generally, in the case of many so-called "extreme sports." Unfortunately, this inference is often (wrongly) made in media reports where experience is all-to-easily equated with competence.

In order to see this, let me present a "thought-experiment". Here is what we know: first, holding all else equal (including risk attitudes), a competent decision-maker is less likely to get caught in an avalanche than a non-competent decision-maker. Second, a competent decision-maker is not a perfect decision-maker and can get caught in an avalanche. Third, it is not very likely that skiers—competent and non-competent (ignoring reckless skiers)—do get avalanched.

So, let's assume for our thought-experiment that with 30 days of skiing per year over a ten-year period a non-competent, yet non-reckless skier, has a 1 in 10 chance of getting caught in an avalanche.[4] Also, let's assume that with appropriate training we can avoid 80% of avalanche accidents.[5] Hence, a competent decision-maker could then reduce their risk of getting avalanched over the same period of time to a mere 1 in 50.

Now adopting for the sake of the thought-experiment these assumptions, consider the following scenario:

You arrive at a new backcountry ski area and you look for a ski partner. You don't know how many competent or non-competent decision-makers are in the area. So to be careful and without further information your confidence is fairly low—say 2 out of 10—that a skier is a competent avalanche decision-maker. Having found a partner, you enquire about her backcountry experience, and she tells you that she skied off-piste for ten years at about 30 days a season and has never been caught in an avalanche.

How much should this increase your confidence that your new partner is a competent decision-maker? Applying analogous reasoning as in the case of Erika the archer, would suggest that you should feel reasonably more confident. After all your potential partner successfully avoided avalanches over 10 years!

However, given the assumption of the thought-experiment (i.e. the probabilities outlined above), and applying Bayes' rule (a well-known theorem in probability theory), shows that your confidence should hardly increase at all: in fact, it should stay at 2.[6] Indeed whatever your prior confidence on the scale from 0 to 10 is, having successfully avoided avalanches over a long period does not constitute much significant evidence for competent decision-making.[7]

Now, of course, this kind of thought-experiment has to be treated with much care. Numerous idealization and simplifying assumptions are made and so our conclusion should be carefully chosen. This much, however, seems reasonable: the result should caution against taking the fact that a decision-maker has successfully avoided avalanches over a long period of time as significant evidence that he/she is competent.

This points to something very important. If competent decision-making in avalanche terrain is somewhere between the ludicrous Joker case who merely guesses and the case of Erika the archer who is extremely reliable and highly skilled, we have to acknowledge that simply looking at the outcome of exercising that competence is not the right approach to finding out whether someone is competent. To put this into a slogan, we can say: *competence (most often) leads to success, but success itself does not indicate competence*. So, we have to acknowledge that snow is a "wicked" learning environment with inconsistent feedback mechanisms that do not always properly reflect the appropriateness of an individual's decision-making.[8]

Competence most often leads to success, but success itself does not indicate competence.

Given this, the next step should be to inquire into what we can take as good evidence for regarding someone as a competent or incompetent avalanche decision-maker. Unfortunately, things are not straightforward and so let me finish by making some short remarks.

1. First, if you repeatedly misjudge the stability of a slope and end up in avalanches, it's time to reconsider your decision-making skills (and/or your risk attitude). Success is not a guarantee of competence, yet repeated failure is a decent indicator of a lack of competence.[9]

2. Second, an indicator of a lack of "full" competence is when a decision-maker puts forth overly confident "certainty" judgments. A truly competent decision-maker will always take into account the inherently uncertain nature of the snowpack and the resulting limits of their decision-making skills. Stability judgments can never be absolutely certain—after all even avalanche experts do get caught in avalanches. Also, let me remind you not to conflate *confidence* with *competence*. Whether or not confidence is rooted in a genuine competence is always a further question—people can be confident yet wholly incompetent! In that context, also be aware of the gender confidence gap: males tend be more confident and self-assured than females, when they are, in fact, equally competent.

3. Third, a lesson to draw from the thought-experiment is that when assessing competence, focus more on *how* people manage to avoid avalanches, not simply *that* they do. For example, competent decision-makers, in contrast to non-competent ones, will typically be able to give *good reasons* for why a slope is safe/non-safe.

4. Fourth, learn the *good reasons*. Knowing what the indicators of (in) stability of a slope are will put you in a good position to assess whether your partner is a competent decision-maker. Also be aware of the *not-good reasons*. Avoid becoming subject to "heuristic traps", don't simply rely on someone's track record in avoiding avalanches, and challenge a judgment that a slope is safe if it is based only on a sixth sense or an intuition—these are usually not based on good reasons.

5. Fifth, engage in dialogue and consciously make decisions. Only if you and your partner engage in an explicit decision-making procedure can you test each other's reasons for a given decision. Through this exercise, you can receive valuable feedback from your peers about *how* you arrived at your decision and whether it is based on good reasons. In this way, you can (justifiably) become more confident in your own competence.

6. Sixth, consider to agree to shift the *burden of proof* in order to make sure to engage in a dialogue. So, instead of assuming that a slope is safe until proven not safe—assume that a slope is not safe until you agree it is safe. Doing this might slow you down, and, yes, making decisions and coming to an agreement can become a nuisance, especially when there is fresh powder to be had, but it will help you make an *informed* decision. Also, shifting the burden of proof might make you less susceptible to a phenomenon called *confirmation bias*. We have a tendency to look for evidence to confirm a given hypothesis and ignore counter-evidence. If your assumption is that slopes tend to be safe (as you might do if the bulletin suggests a low danger), you might end up ignoring, by being subject to such bias, important evidence that suggests otherwise. So, the main advice is simple: *rationalize your choices and make them explicit*.

After all, it's your life your are talking about.[10]

References

Ebert, P. A. and Photopoulou, T. (2013). Bayes' beacon: avalanche prediction, competence, and evidence for competence. In International Snow Science Workshop Grenoble – Chamonix Mont-Blanc, pages 363–370.

Ebert, P. A. and Robertson, S. (2013). A plea for risk. In O'Hear, A., editor, Philosophy and Sport, London Lecture Series. Cambridge University Press.

Llewellyn, D. J., Sanchez, X., Asghar, A., and Jones, G. (2008). Self-efficacy, risk taking and performance in rock climbing. Personality and Individual Differences, 45(1):75–81.

McCammon, I. (2004). Heuristic traps in recreational avalanche accidents: Evidence and implications. Avalanche News, 68:1–10.

McCammon, I. and Hägeli, P. (2007). An evaluation of rule-based decision tools for travel in avalanche terrain. Cold Regions Science and Technology, 47(1-2):193–206.

Zweifel, B. (2012). Jung & wild vs erfahren. Bergundsteigen, 4:78–82.

Philip is as an Associate Professor in Philosophy at the University of Stirling, Scotland. He works in epistemology with interests in (amongst others) norms of reasoning, (Bayesian) rationality, and more recently decision-theory. He also has academic and personal interests in studying notions of risk and how to justify risk-taking. Since the age of four, Philip has been skiing and snowboarding and he was fortunate enough to spend numerous seasons in Chamonix. ❄

[1]Compare here (Ebert and Robertson, 2013).
[2]In the case of rock climbing this is shows in (Llewellyn, et al., 2008). It is tentatively suggested for ski-touring in (Zweifel, 2012).
[3]Compare (McCammon, 2004).
[4]We shall be very careful when employing such numbers since it is difficult to find relevant empirical data and so there is a lot of uncertainty here. In (Ebert and Photopoulou, 2013) we offer some reasons why a lower risk (1 in 23) does not seem unreasonable. The phenomenon outlined below will be even more pronounced of we underestimate the relevant risks. This fact and considerations of simplicity motivate the use of 1 in 10.
[5](McCammon and Hägeli, 2007) have assessed a wide variety of decision tools and they suggest that between 60-92% of accidents could be avoided. So for simplicity, we here assume 80% and assume a competent decision-maker is understood as someone who adheres perfectly to such decision-making tools.
[6] Allowing decimals, your confidence should rise from 2.0 to 2.14, i.e. not very much at all.
[7]For an explanation of the calculation and the scale, see (Ebert and Photopoulou, 2013), section 5.
[8]This is a theme that is also discussed in the article "Situational Awareness Part 3: Projection" in this issue of TAR. In fact, many of the suggestions offered here are also discussed in that article.
[9]Compare scenario 1 in (Ebert and Photoulou, 2013) on p.367.
[10]For comments on earlier drafts of this paper I like to thank Nora Hanson, Bjørn Michaelsen, and the participants at his avalanche workshop in Skjervøy, Norway in April 2014, Walter Pedriali, Theoni Photopoulou, Simon Robertson, and Bruce Tremper.

SITUATIONAL AWARENESS

Part 3: Projection

By Doug Krause

Projection: the act of visualizing and regarding an idea or the like as an objective reality.

—Dictionary.com

TURKEYS AND TOPOMANCY

This is the final installment of the Blue Collar Guide to Situational Awareness for Avalanche Aficionados. Situational awareness (SA) is the process we use to support our decisions and actions in dynamic environments. It is the foundation of decision-making and purposeful action.

Part 1, Perception (TAR 32.4), focused on the gathering of information. We learned that being an astute observer will get us most of the way towards being the ball. Part 2, Integration (TAR 33.2), focused on comprehension. In Part 2 we learned that bad inputs will corrupt the entire process, and also that our beliefs should be regularly critiqued and reassessed. Part 3, Projection, discusses how we think about what comes next. Projection describes a forecasting process and our last opportunities to reassess prior to decision and action.

All three components of situational awareness can be corrupted by bad input, physical adversity, and lack of self-awareness. All three will benefit from planning, pausing, and communication with your team, partner, or inner angakoq.

WHAT IS PROJECTION?

Study the past if you would divine the future.

—Confucius

The projection process uses the inputs from Phase 1 and 2 (perception and integration) to create scenarios of what may happen next, with or without action. Starting from what we perceive and what we believe about the problem at hand, we press the fast forward button on a mental model to see what will happen next. It's a 'what if…' game. The movie plays according to one's experience with or knowledge of the problem. It is further guided by one's ability to anticipate changing inputs to the scenario. These thought experiments provide an analytical check for the intuitive pattern matching associated with instinct.

Projection should articulate expectations. The expectations describe potential outcomes that will highlight the validity of a forecast. If we add expectations to a forecast, we build feedback into the process. When I place an explosive on that rock band, I expect it to avalanche. The other rock bands we shot today have all avalanched. If this one does not, I realize that my understanding of the situation is missing something and I may need to reassess.

The moving picture shows of mental simulation can be played in reverse. One compares current state with previous expectations to evaluate situational awareness strength. If what I thought was gonna happen didn't, then I reckon I got some re-thinkin' to do.

Planning the next round of observations primes the next perceptual phase; it lubes our cycle. We know what to look for if the forecast identifies important cues. If I forecast high instability, I expect to see obvious signs of instability and will purposefully look for them during the perceptual phase.

Projection involves forecasting the unknowns in our environment; this includes human forecasting. Human forecasting is arguably more important than beer. Maintaining a high level of operational awareness requires us to consider what we and those around us will do next. As human forecasters we look within and examine our own belief structure, and we look outward and attempt to gauge the underlying motivations and beliefs of those around us. This awareness guides our assessment of how shit is gonna go down. If human factors are a critical component of avalanche safety, forecasting the influence of human factors is equally critical.

WHAT CAN GO WRONG?

Predictions are very difficult, especially about the future.

—Niels Bohr

It should come as no surprise that a slew of factors degrade and debunk the forecasts we build during the projection phase. Nostradamus was distracted by shiny things. The fast forward function of our mental models is extremely vulnerable to bad input. Flawed observations and incomplete mental models of the problem will lead to faulty projection. Weak mental models make novices particularly vulnerable to projection failure.

Over-reliance on current trends can corrupt projection. Part of the nature of dynamic systems is that shit changes. Everything may be hunky-dory until it's not. Expert forecasting requires being highly attuned to changes in the environment. *Did you feel that wind shift? Notice how it gets a little steeper over there and the aspect twists slightly?* As the variables bob and weave, hazard and relative exposure will dance in time. Keep pace.

The projection phase is vulnerable to all of the cognitive biases and heuristics that are the hobgoblins of decision-making. Damn hobgoblins. This is our last chance to exorcise them before making a decision. A survey of the h-gobs is beyond the scope of this essay. The FACETS acronym and a host of scholarship on the subject provide ample resources for honing our awareness of the cognitive traps that threaten the path to strong decisions.

How valid are the familiar patterns that support our mental simulations? Without feedback, experience does not translate to expertise. The absence of evidence of a poor decision is not evidence of the absence of a poor decision. Maybe read that last line again, it should probably be tattooed on the face of everyone that frequents avalanche country, in reverse, so we can read it on our buddies' faces. *We really nailed that line!* Did we nail that line? Statistically, Russian roulette has more winners than losers, yet the older ranks of high-stakes gamblers are thin.

Failure to recognize a flawed decision train leads to reinforcement of flawed patterns and models, and that introduces systemic problems. We all need to understand that experience is not the same as expertise. Most folk that frequent avalanche country are regular recipients of good luck. Luck is the enemy of expertise. That would be a more manageable tattoo.

HOW CAN WE DO BETTER?

Plans are nothing, planning is everything.

—Dwight D. Eisenhower

Fortunately, like all the other facets of SA we've discussed, improving projection is a straightforward process that depends mostly on practice, meta-cognition, and communication. Practice allows good habits to become automatic. Meta-cognition (thinkin' about yer thinkin') checks our internal biases. Communication diversifies our perspective, enables feedback in a wicked learning environment, and can further mitigate biases and decision-making short cuts.

Take a moment to pause for projection, and check your instincts. Practice checking yourself for loss of SA before you forecast, decide, and act.

Clues to Loss of SA:

- Excessively High or Low Stress
- Anomalous or Ambiguous Information
- Tunnel Vision/Fixation
- Unmet Expectations
- Confusion

High stress levels are often caused by environments where it is difficult to process everything going on. Conversely, low stress levels may warn us of complacency. Anomalous information should grab our attention like a cat on fire, and ambiguous information should arouse suspicion like a dog playing with matches. If we become overly fixated or preoccupied with a given issue, that decreases our sensitivity to everything else: tunnel vision. A failure to realize planned targets or expectations must lead us to question why. What is missing? If you are confused, that means, by definition, you do not know what is going on. That's a problem.

It's never too early to start thinking about what could go wrong. *Photo: Sallie Barney*

Forecasting exposure mitigates unexpected complexity. *Photo: Doug Krause*

Strive to identify what is unknown, including the potential for unknown unknowns. A whiff of certainty may degrade the perpetual enquiry that is required to maintain situational awareness. If we dismiss the role of uncertainty in our projections, it will catch up to us sooner or later. Just ask the turkey. Life was all glorious sloth and gluttony until the day the axe came and they stuffed his butt. Asking questions instead of positing answers will help identify unknowns. *I love corn and breast massage but why are the humans being so good to me?*

For a novice, the level of uncertainty can be overwhelming. Communication and feedback from expert sources help establish what are relevant data and valid patterns. Trying to anticipate the decisions and opinions of an authority helps develop projection skills and mitigates the expert halo trap. If you're doing avalanche mitigation work, you're lucky. Control work allows you to test your stability forecasts. Embrace that opportunity. The rest of the world suffers from the lack of feedback inherent in avoiding avalanches; confronting avalanches puts feedback up in your face.

Lack of certainty indicates one should forecast multiple scenarios with a set of expectations, or prioritized observations to go with each. Failure to realize those expectations will indicate a potential loss of SA or change of circumstances. Either we did not have our finger on the pulse or shit changed, as shit is wont to do.

Planning and forecasting frees up brain power to deal with immediate complexity. Our mushy gray deciders process previously considered scenarios more efficiently than whiskey tango foxtrots. That efficiency enables us to better manage complex environments. Forecasts are even cheaper than forecasters. Always consider more than one option. If we don't have options, our plan is structurally weaker than a Colorado snowpack.

Becoming familiar with our own and our team's prominent biases, strengths, and weaknesses will help us better assess the quality of individual and shared team SA. This meta-cognition and empathy is critical for optimizing the decision-making that precedes action. If I know that I am prone to accepting higher levels of exposure in familiar terrain, I should understand that increases my vulnerability. If I know that my partner tends to underestimate the consequences of avalanche events in familiar terrain, that subtly ups our level of acceptable risk. Forecasting for familiar terrain with that particular partner should therefore include a heads-up that if something goes wrong, it may catch us by surprise in a compromising position: drawers around the ankles when the door flies open. Not really what we're looking for. This is human forecasting. If you value you and yours, please practice, and wear some suspenders when you approach that cornice. And hopefully causes us to stand a bit father from the edge of the cornice in the morning.

Projection challenges become more manageable if we break them down and practice in subsets. Practice forecasting how long it will take to complete a given task. Practice forecasting natural and triggered avalanche activity in specific contexts. Practice forecasting what the boss is going to do next, or what a partner thinks, or how one will respond in a given situation. When you blow the forecast, try to figure out why, so we can do better next time. Otherwise, you're blowin' smoke. Projection without critique is like speaking without listening: much of the value just sublimates into the sky.

ERRARE HUMANUM EST

Life doesn't give you all the practice races you need.

—Jesse Owens

I believe that avalanche education should begin with communication, proceed to situational awareness, then tackle decision-making, and only after that let folk touch the car keys. The Magic Beans of communication are covered in TAR 32.2. Each part of this series contains a description of one phase of situational awareness, a list of things that can go wrong during that phase, and suggestions for how we can improve. My goal is to provide a bit of a path to follow in our quest to achieve total consciousness.

It's worth repeating that experts will unconsciously execute the phases of situational awareness in parallel as well as consciously in sequence. This reflects a duality of intuition and analysis that is the hallmark of true expertise. I've leaned towards the analytical concept of SA in the hope that novices will be able to use it as a learning tool and experts as a complement to their intuitive skill. I hope there is something in here for everyone. In summary:

Festering Sores:

- External distractors like weather, clients, operational hubbub
- Internal distractors like stress, fatigue, euphoria, and complacency
- Flawed observations
- Flawed understanding
- Failure to reassess
- Individual and group biases and heuristics
- Failure to adequately project/plan/forecast
- Mistaking experience for expertise

Soothing Unguents

- Prioritizing and planning specific observations
- Actively refining and reassessing your mental models
- Consideration of multiple contingencies
- Building feedback into the decision-making process
- Deep breathing, meta-cognition, communication, and tacos

Thus concludes this three-part foray into the basics of situational awareness. I tried to balance the relevant scholarship with an accessible tone and a perspective from the trenches. The trench tone is meant to resonate with the target audience. This is by no means a comprehensive examination of situational awareness. I think it provides a reasonable overview with a focus on how we can do better.

REFERENCES

Adams, L. A Systems Approach to Human Factors and Expert Decision-Making within Canadian Avalanche Phenomena. 2005. [Master's Thesis] Retrieved from http://static1.squarespace.com/static/53fbfe1ce4b04ce86372f366/t/5445c920e4b070d5e53fc455/1413859616057/adams.pdf

Endsley, M., Robertson, M. Training for Situation Awareness. 2000. Retrieved from http://www.takewinginc.com/documents/SATrainingchapter.pdf

Hammond, Grant T. The mind of War: John Boyd and American Security. Smithsonian Institution Press, 2001.

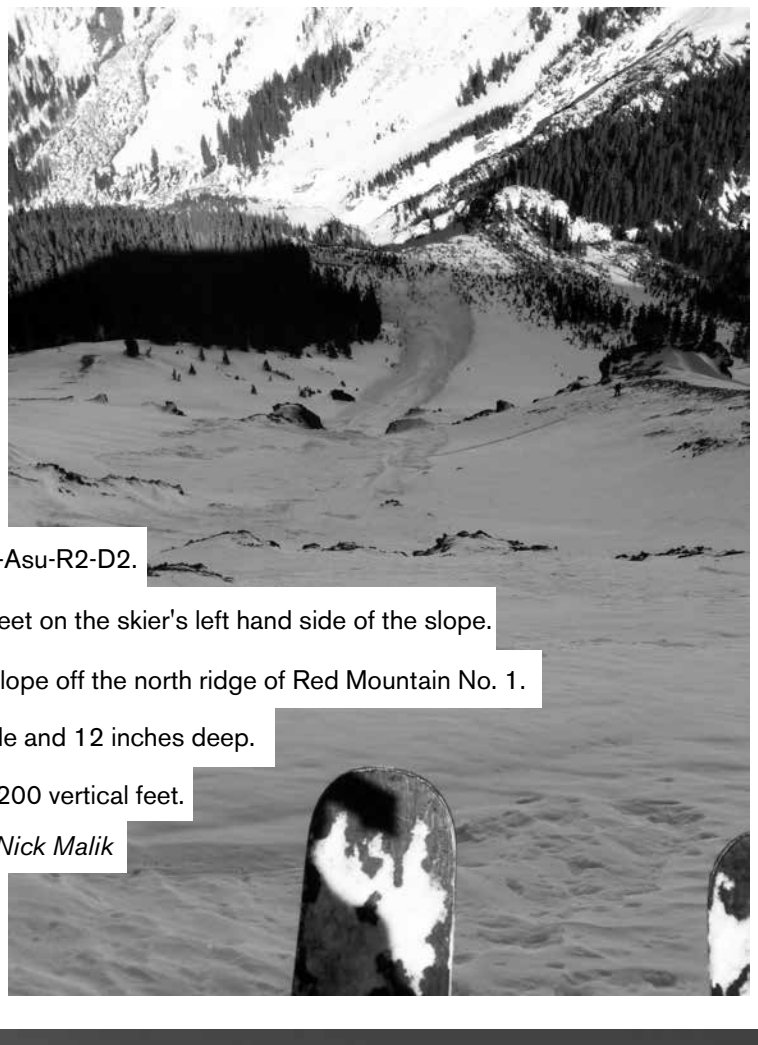
Kahneman, Daniel. Thinking, fast and slow. Macmillan, 2011.

Klein, Gary A. Sources of power: How people make decisions. MIT press, 1999.

Taleb, Nassim N. The Black Swan:: The Impact of the Highly Improbable. Random House LLC, 2010.

Doug Krause divides his time between Silverton, Colorado; Hakuba, Japan; Valdez, Alaska; and Lima, Peru. Tacos, sashimi, salmon, and ceviche. So hungry. ⁂

SLIDES:
Snapshots & Stories



We called this avalanche SS-Asu-R2-D2.

It was triggered at about 12,150 feet on the skier's left hand side of the slope.

The location was on a NE facing slope off the north ridge of Red Mountain No. 1.

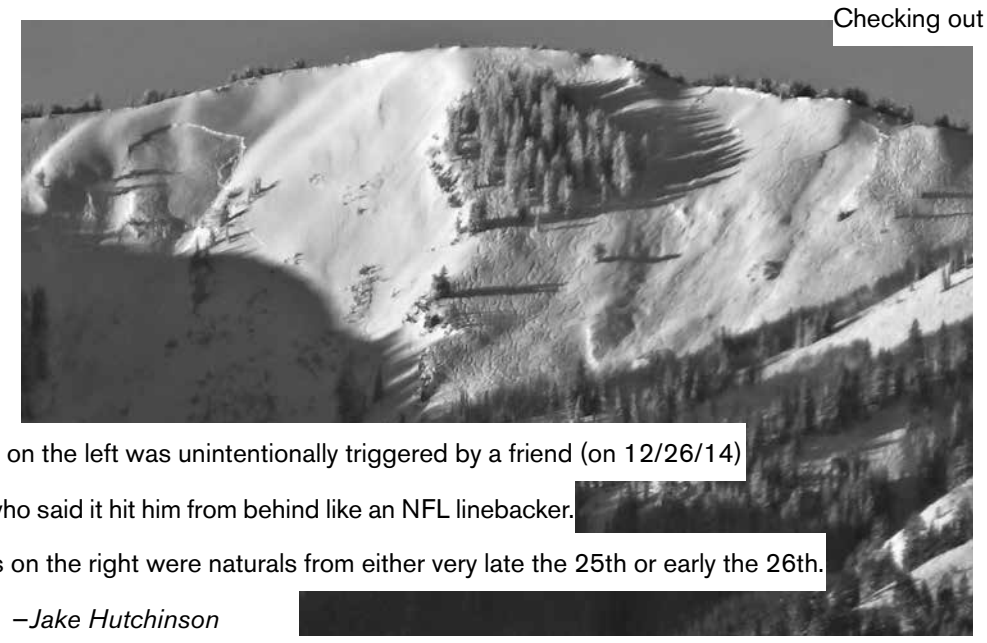
The crown was about 30 feet wide and 12 inches deep.

The avalanche ran about 1000-1200 vertical feet.

–Nick Malik

An avalanche from serac-fall from the 13K plateau on Mount Hunter.

–Jordon White



Checking out the sensitivity of fresh wind slab on a level 1 avalanche class.

The Avalanche on the left was unintentionally triggered by a friend (on 12/26/14)

who said it hit him from behind like an NFL linebacker.

The two smaller slides on the right were naturals from either very late the 25th or early the 26th.

–Jake Hutchinson

Mt. Oliver, Teton Pass.

–Pierre Sarthou

RISK TOLERANCE & SELF-AWARENESS

FORECASTER ESSAYS

By Blase Reardon

Author's Note: *The following two essays are slightly modified versions of two forecast discussions that I wrote about a week apart in January and February, 2015. They're organic, in that they're both based on unexpected conversations. But those discussions seemed to illustrate abstract ideas about decision-making and human factors. My aim was to show how those notions can appear and feel in our everyday lives, so we might become more conscious of their influence.*

GOOD DRIVER DISCOUNT

A recent conversation illuminated how people can perceive the risk involved in their decisions and actions very differently than others do. The subject was driving skills, but it could just as well have been backcountry travel. I'll paraphrase the conversation, and I have slightly altered and exaggerated some details in the interest of making a point.

The conversation was prompted by a comment that a friend wouldn't have to speed on her morning commute if she left home 15 minutes earlier. She offered a spirited defense of her driving. "Speed limits are suggestions. There's no need to drive less than 5 mph over the speed limit if there's no inclement weather. People that drive less than the speed limit are dangerous."

Her audience wasn't buying it, so she escalated her defense. "I'm a good driver. I've only had one wreck. And that was because of black ice." The car incurred damages of $10000, but she only paid the deductible, so it didn't count as a serious accident in her mind. "And two tickets.", she added.

It came out that she'd only learned to drive in 2009. A listener pointed out that three incidents in five years was a pretty high rate of getting into trouble. She argued that the second ticket shouldn't count, as she was speeding to pass a semi. "Don't you think that driving next to a semi is unsafe?" she asked the trooper. She threw in that it was her birthday, but he gave her a ticket anyway. "I couldn't flirt my way out of it, like I had other times." The "other times" were three more traffic stops in which she hadn't gotten a ticket. That meant a rate of more than one incident for each year of driving.

"That's not bad. I'm a good driver." Someone noted that some people go their whole lives without a ticket or an accident. "They're probably the people going 10 mph below the speed limit and making it dangerous for everyone else."

She then told a story about driving 100 mph on I-70 in a borrowed Audi because the car is designed to hold the road better at high speeds. She offered to drive anyone home. There were no takers.

My friend seemed to feel that deft car-handling skills equate to safety. Many of her defenses sound familiar; I've heard similar sentiments in conversations about skiing and riding in the backcountry. Somehow, the unintentionally-triggered slides and the near misses don't count because of some circumstance specific to that incident. They become confirmation of skills rather than lessons. An avalanche flank 15 feet from your track isn't a close call; it's proof you knew how to pick your line. Flawed conclusions like that are easy to draw in a wicked environment like the backcountry, where irregular feedback promotes learning the wrong lessons from our experiences, and encourages an illusion of skill.

I don't know whether my friend drives as recklessly as she sounded in that conversation. Nor the balance of over-confidence and expertise of anyone I meet in the backcountry. I do know I aim to second-guess my own claims to expertise and skill. I try to imagine what they'd sound like out of context, after an accident perhaps. Andre Roch 's famous quote, purportedly made after one of his own near-misses, applies here: "The avalanche doesn't know that you are an expert." It's the quality of situation-specific decisions that matters. And every close call counts. **The backcountry doesn't offer a good-driver discount.**

GOT RELIGION NOW

As I touched in an discussion, language that minimizes close calls can reinforce overconfidence and an illusion of skill. A close call doesn't count or isn't that serious, because it's an exception, because nothing really happened. It must be our abilities that made the difference. And with these abilities, we can take more chances.

I've wondered how to break that cycle. Recently, I heard how it happened for a friend and occasional ski partner. We were talking while skinning on a mild day. He's had at least three close calls, two of them involving large avalanches. He's never seemed to shrug off the incidents, and he takes avalanche safety seriously. But still, the hits just keep on coming. Enough so that he and his frequent partners earned the nickname "The Wrecking Crew." The most recent involved a small avalanche earlier this season.

I was surprised to hear that he'd hardly skied in the backcountry since then. I figured it was just conditions. "No," he said, "it was like a switch got flipped. Suddenly it just seemed so risky."

The defining incident had happened early one morning, on what was supposed to be a casual one-n-done with some of the Wrecking Crew. The group had an inconclusive discussion about a line down the bowl, with at least one member of the group arguing that they stay away from the bed surface of an older slide. It had been reloaded with new snow and a few days earlier someone had triggered a second, smaller slide that released the new snow on the other side of the bowl. My friend watched the first skier nonetheless turn into the old bed surface and trigger a small slide that briefly knocked him off his feet. He recovered and escaped out the side.

Several things made this incident feel different for my friend. The skier who triggered the slide was recovering from knee surgery. My friend said that while he watched the skier struggle with the debris, "I kept thinking about his knee and how it would suck for him to get hurt again."

This incident was also more of a surprise, unlike the previous ones, when he knew he was pushing the line and far more prepared for something to go wrong. "It was supposed to be a casual day. We weren't really going to be exposed to much danger. The terrain and the danger were moderate. Yet something still happened. I realized it could happen anytime."

The big thing, though, was a conversation with one of the others in the group when they arrived back home. "We looked at each other at about the same time and said, 'That was not ok, was it?' And it was like waking up after one too many frat parties."

My friend and I had a good tour together that day. I didn't ask him if skiing in avalanche terrain felt different this time. I don't know that there's a recipe for replicating his come-to-Buddha moment. I do see some elements that seem common to people who aren't overconfident: a visceral sense of the consequences of a slide, an awareness that avalanches are unpredictable and ultimately unmanageable, and lastly, a willingness to l**isten to friends who don't write off close calls.**

Blase Reardon learned to drive in a 1976 Oldsmobile Vista Cruiser station wagon, a perfect ride for spinning donuts in snow-covered parking lots in Ohio. He thinks he got pretty good at controlling a skidding vehicle on snow. He nonetheless rolled an old land cruiser on snow-covered roads more than once. Now he tries to drive like an old Buddhist monk: one hand on the wheel, one hand clapping. ❄

Kessler Peak: December 27, 2012

Miscommunication was the biggest problem of the day.

By Trent Meisenheimer

My morning started out like most winter mornings: wake up, read the avalanche forecast, which stated:

> There is a CONSIDERABLE avalanche danger today. Experience along with careful route-finding procedures and following safe backcountry protocol is a must.

However, what caught my attention was the deeper weakness in the snowpack, with a likelihood for triggering a slab avalanche on a deeply buried weak layer….

A foot of new in the Cottonwood Canyons: I knew it was going to be a good powder day!

After a quick chat on the phone with my main partner, who happens to be my father, we decided to go to Kessler Peak in central Big Cottonwood Canyon, Utah.

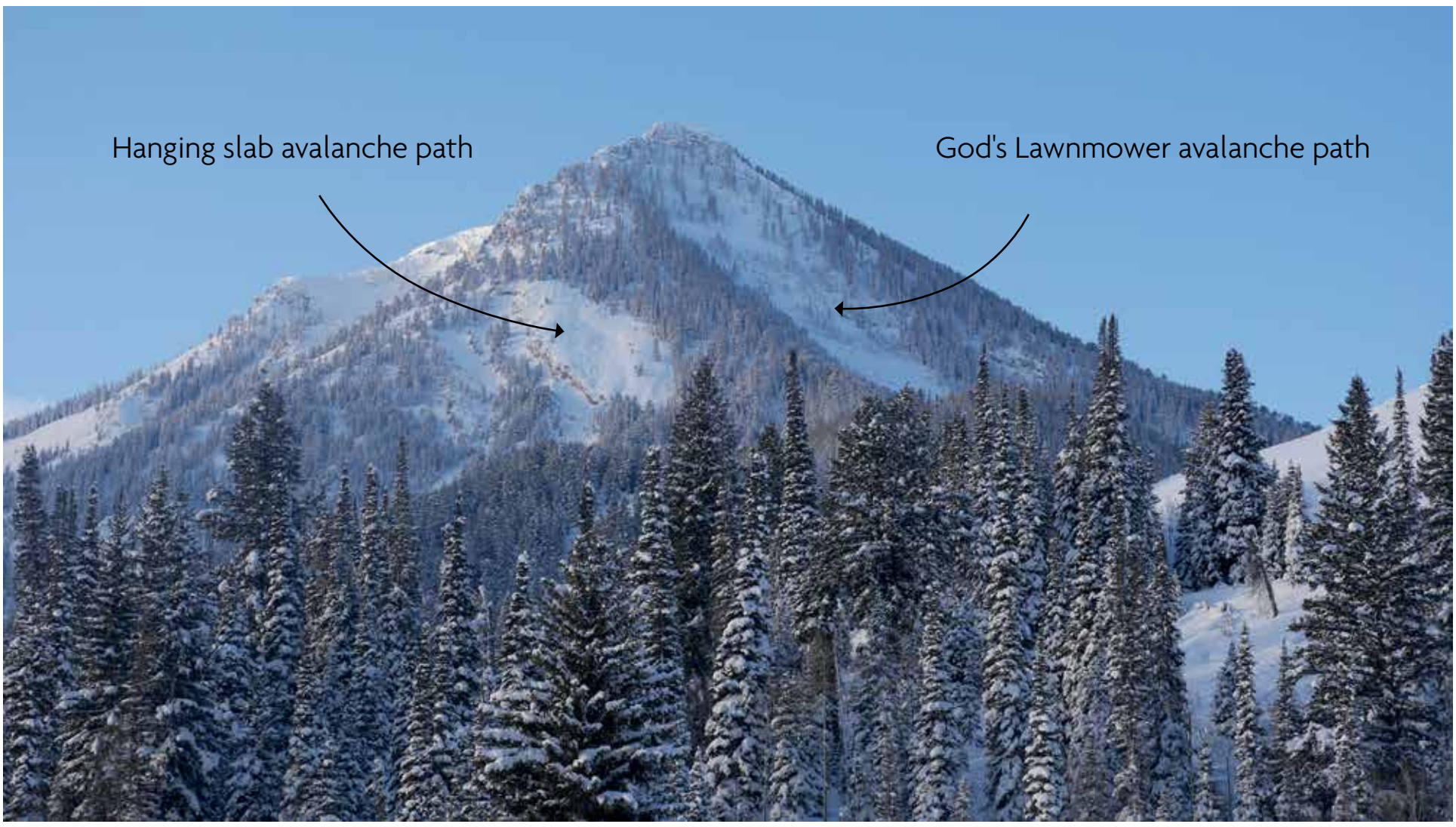


Photo by Trent Meisenheimer

Our plan for the day was to follow the treed ridge in the center of the photo up to a point where the trees start to thin out. This is considered a relatively safe option for this terrain. However, there is lots of very dangerous open terrain on either side of the treed ridge.

There are many pros and cons to trees vs. open slopes. Trees are nice because they can act as anchors for the snow, but this is a double-edged sword. Because these trees become our worst enemy if there is an avalanche, they become the baseball bats of the backcountry. A quarter of the people who die in avalanches die from trauma, from hitting trees and rocks on the way down the mountain, thus open slopes are generally safer options because you're not hitting trees on your way down the slope. But in this case, the open slopes are steeper and unsupported, not a good choice for this day and its avalanche problems.

At the top of our first climb my dad and I discussed our descent plans, trying to figure out how to carefully navigate the dangerous terrain that surrounds us. After a short discussion we agreed to ski the ridge roll, and then at a certain point we would poke out carefully onto the looker's right side of the hanging slab avalanche path.

He skied first….

Dad kept a pretty straight fall line and went out of sight, after his first two turns you knew it was good as he was engulfed in snow and let out a little hoot, it was face shot blower overhead conditions, classic Wasatch powder. I started to ride down and was skier's right of his track. I descended about five hundred feet, working to my right of the roll heading for the side of the hanging slab when I noticed that I was the only track on the far skier's right. I then realized had been separated from my dad. I stopped and let out a yell.....No response.

I quickly scanned the terrain and for sure saw no tracks to my right. I moved down the slope a bit further, moving now towards skier's left and came across a couple of tracks. Yelled again… still no response. I continued moving down and left stopping on the center part of the ridge roll and yelled yet again....finally a faint yell back.

At this point I just stopped and decided to wait here. However, after a couple of minutes went by without seeing or hearing from my dad, I yelled again.... and got no yell back this time. I thought no big deal he probably went too low and had to put the skins back on to gain the ridge. After five minutes I started to worry again and decided to drop lower down the slope and cut skier's left to find his track, which puts you off the ridge roll and into the main avalanche path "God's Lawnmower: " (Center Path of the photo) the exact terrain we were trying to avoid for the day.

After dropping through the trees working left again, I came across a fresh avalanche debris pile. Oh my god, my heart sank and I quickly started to think the worst. I began to panic and a full hit of adrenaline rushed through my body and my hands began to shake. My world instantly shrunk, I felt all alone and scared. I started to hate the dark snowy trees around me. I ripped out my avalanche beacon and switched it to receive and tried to slow my breathing. My beacon wasn't picking up any signals, it was silent.

Just one month before my friend Alecs Barton died around the corner on the northwest face of Kessler.

I told myself to calm down and think this through. I started by analyzing the avalanche debris. As I scanned the boundary of the avalanche I quickly realized the debris wasn't very deep, BUT deep enough to bury a person. It looked to be about 75ft wide, and looked like the avalanche had traveled a long ways down, but never piled up super deep.

Then I saw a set of ski tracks coming out of the avalanche debris, but this didn't make me feel any better as other people were in the area as well. It's possible that it was another person's track. I checked my beacon one more time and listened vary carefully to hear any faint beep....nothing.

Overview photo with recent avalanche fatalities of two friends. Alecs Barton, January 28th, 2012 and Craig Patterson April 11th, 2013.

The Red line was our intended descent, the one I thought we agreed apon. The white line is my dad's line and the circle marks where the avalanche was triggered.
Photo by Bruce Tremper

I decided I would follow this track down and hopefully find my dad waiting at the bottom. I turned my beacon back over to transmit and raced downhill next to the track yelling and shouting his name.

When I reached the end of the ski track, I found where someone put their skins back on and started climbing uphill. I unstrapped from my board and raced to switch from downhill to uphill mode, I extend my poles and put the skins on, ready to start hiking. I stripped all my layers to keep cool because I was panicking and breathing hard.

I began to doubt myself. Thoughts of negativity began to overwhelm me, "Should I have searched that debris pile better? Did I just drop too low and have no chance of getting to him in time? Is he still buried? I can't believe my dad is going to die in an avalanche. This can't really be happening. I began to cry and started losing it as I hiked through the lonely cold trees. Five minutes went by like this…

These thoughts were painful and I soon took another breath and started to hike. I screamed one last time and *finally* received a welcomed yell back.

Whew.

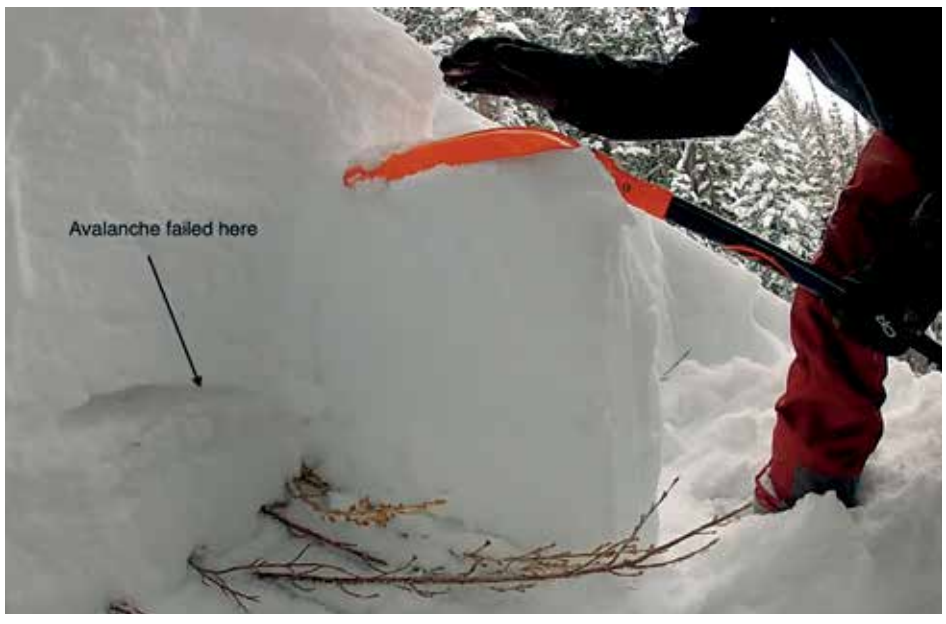
Mistakes we made:

- **Not clearly communicating our thoughts properly.** I thought we were going to descend the ridge roll and then work right into the hanging snow field. My dad was clearly thinking the left line into God's Lawnmower and this split us apart from the beginning.

  It's still hard for me to gather the psychology behind what happened in our conversation before we started skiing. How can two people both be in complete agreement on where they are going and then get so separated? How could a plan be verbally described so clearly but yet so distorted in our own minds? Communication is the hardest and one of the most important aspects of backcountry skiing.

- **Skiing a steep break-over with no partner or backup.** Dad couldn't make it over to me, so he skied through the trees in a steep slot. On the third turn, on a rollover, he triggered a soft slab avalanche which failed above a crust on facets. It was three feet deep and 50 feet wide and ran 500 feet.

- **Not realizing the shallower snowpack area.** This was at exactly 9000 feet and was the precise elevation band to have the structure alluded to in the forecast: a very likely spot to trigger an avalanche.



- **Not working as a team.** If we had good communication and were working together as a team while descending the slope, this event probably never would have happened. Furthermore, had we been together when approaching the steep breakover we could have discussed, managed, or avoided it rather than just skiing it.

- **Not doing a complete search of the debris pile.** While I have mixed feelings on my decision to leave the debris pile. I think this is a situational call and every avalanche is different and each rescue will have its own complications.

- **Letting 5 star powder cloud our judgment.** It was really good skiing!

I don't think our terrain choice for the day was the issue. The biggest problem was the miscommunication and being separated from each other. This is what led to confusion and put us into the exact terrain we wanted to avoid.

My dad and I later had a very warm heart-to-heart talk where we talked about our mistakes and what to do next time to better work as a team in avalanche terrain.

As I strive to gain expertise in the mountains I think its important to look at our mistakes and openly share our experiences. Thankfully this time we both got the chance to learn and grow from our mistakes.

Trent Meisenheimer grew up in Salt Lake City Utah, and has been skiing and snowboarding the Wasatch Mountains since the age of two. He can be found most winter days pursuing his passion- hiking the backcountry, shredding Utah's famous powder. He also works for the Utah Avalanche Center where he is continually seeking knowledge for snow and avalanche science. In 2009 he completed his Level One Avalanche Operations course in Canada and in 2013 successfully completed the Level 2 Avalanche Operations course. He devotes himself in the winter months to avalanche outreach and education. In the summer months you can find him clinging to the side of a rock wall or floating down one of the many scenic rivers in the western U.S. Trent lives in SLC and is a full time Mechanical Engineering student at the University of Utah. trent@utahavalanchecenter.org

Using Social Media To Get The Message Out

By Dan Moroz

In today's world everyone seems to be connected by some sort of mobile device. Many different platforms exist but one of the most popular and easy to use is Facebook (FB). This free application works on any computer or smart phone and is user friendly to attach images to written text. Depending on how many friends one might have, information can be quickly displayed to a large audience and thru "sharing" to even a wider population.

The included information can be tailored to a region of focus or to a broad spectrum of areas. The beauty of this platform how easy it is to pick and choose content that is relevant without being too wordy. Specifics can be outlined and a specific hazard can be identified, image included as an example, and you are done. With smart phones you can even message conditions "real time" and get the observation "shared" to users who are already in the field. This is not to take the place of the avalanche information centers reports but those are normally only once a day and have to be concerned with large regional info reports. A FB post can be very localized and updated immediately.

Several years ago I suffered a season ending injury on the first day of the season. During an extensive convalescence period the boredom was unbelievable and I wanted to be useful in some way. Being an avid FB user I thought, *"Why not put out a little local weather report with avalanche conditions"* to perhaps get some backcountry user to at least think for a second about their route for the day. After nearly 30 years of avalanche forecasting for a resort and being an active AAA certified instructor, I could see that I could include pertinent information, some education, and put the bug in someone's ear that a hazard exists and to be aware of it.

This began a daily post that has run for over four years non-stop (summers too). I have developed a friends base that is local, regional, and also worldwide that has been fun to put together. Recently, posts have been generating good discussions between people who are seeing similar events in the backcountry within their locale and then add their own interpretation and pictures of events or snowpack structure.

Another great tool is that if someone writes a relevant article on a snow-related subject in a different forum, these can usually be posted in their entirety. Video clips and examples of near misses can be inserted from YouTube. The "GOPRO Generation" has been a real asset to avalanche education as exceptional footage can be found daily and furthers drives home the point that hazards exists and what can we learn from miscues in the backcountry.

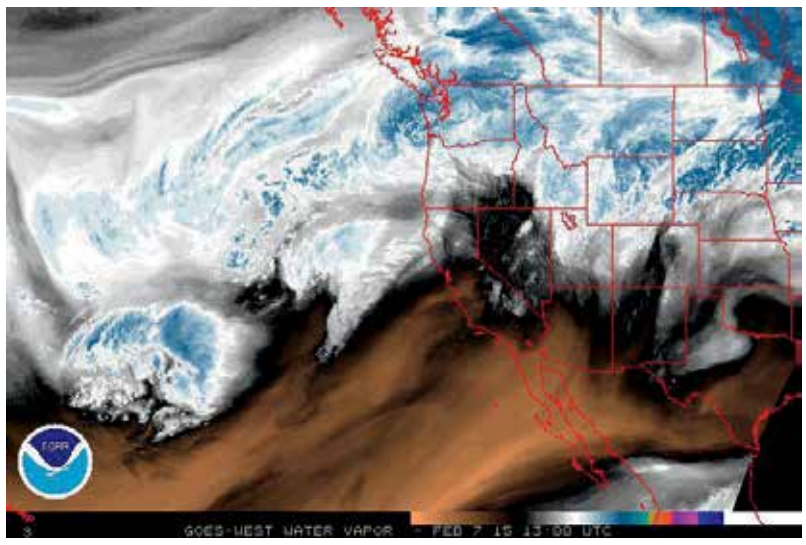
FaceBook will never take the place of detailed weather and avalanche reports from an avalanche information center and these posts are not designed to do so. However, as educators we are tasked with how best to get important information out. A good FB post can wade thru the weather and hazard evaluation, pick the pertinent highpoints for a specific area, add local reports, and become the "Readers Digest" condensed version.

The following is an example of a FaceBook post that describes in short the current weather picture along with avalanche hazard conditions for a localized region. This helps to hone in on the micro-picture verses the macro-picture for snowpack understanding.

Dan Moroz has been a AAA certified instructor since 2004 and has twice presented at the ISSW and numerous times at CSAW. He has been a member of the Copper Mountain (Colorado) Ski Patrol for 29 years and is currently the fire marshal for the resort's fire department. Dan resides in Summit County, Colorado where he is an avalanche mitigation consultant and an adjunct instructor with Colorado Mountain College, teaching Level 1&2 avalanche courses.

Dan Moroz added 3 new photos.
February 7 at 7:47am · Edited ·

Colorful morning sunrise as some moisture is slipping in from a very strong Pacific storm. Unfortunately a stubborn and persistent high will only give in for a day and allow some moisture later into our area but rebuild Sunday night. It will allow some moisture to creep in again Tuesday but it looks to strengthen mid-week and become like a boulder in a stream and shunt weather around us. Some eddies (as like the area behind our stream boulder) will allow some moisture in from... time to time but nothing major. We are lucky for what we have as to our west is rather thin snowpack wise. Avi wise it looks like our "mini" slide cycle has run its course where naturals have slowed down and triggered slides are hard to initiate. This is a weird time in avalanche triggering potential. Yes it is more difficult but the outcome is larger as the surface is developing a slab via consolidation of the new snow. The weaknesses just below the surface are still there but a little less reactive. So if you see cracking ahead of your equipment or hear the "whumpf" sound of a buried layer collapsing take heed. Mother Nature is trying to tell you something.



So the first avi picture is from the south side of Jacques Peak above the old Searle Pass road. Very large terrain feature failure that if you blow the foto up it shows multiple aspects and a widespread slide. This slid on some layer separating the new wind loaded snow from the existing snowpack. (I would assume either surface hoar or near surface facets on top of a sun crust.)

The second foto is the top of the Iron Mask on the out of bounds east aspect of Tucker Mountain. (Yes Copper's boundary is just adjacent to this). This explosives released slide was quite extensive and the fx line pulled back quite a ways from the terrain roll over on the lookers left side. This again is a sign that the adhesion between the new and the old snow is weak so the snowpack depends on the tensional or pull apart strength of the snowpack. When it fails however, the fracture line is wide and encompasses a lot of snow. Bottom line is that there are some great turns to be had but there are some disturbing "signs" on the western side of the county from Fremont to Vail Pass of buried hazards. Keep that "what if" in the back of your mind so you have a way out already decided if needed.

Book Report: Secrets of the Greatest Snow on Earth

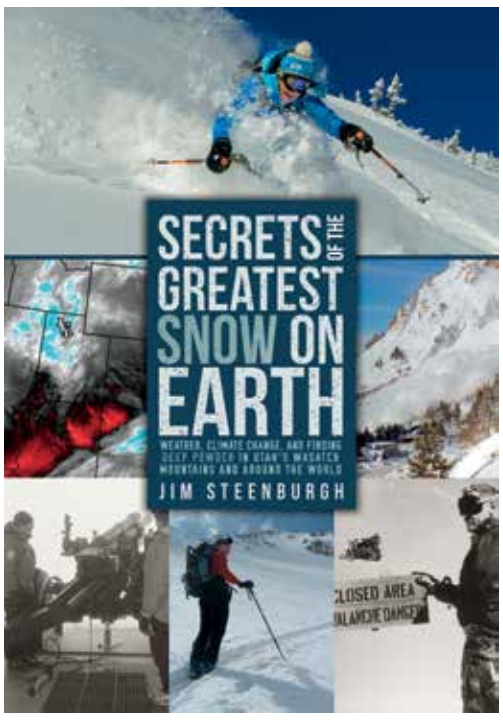
By Jake Hutchinson

Does Utah really have the greatest snow on Earth? Is it the lightest and deepest? Is it the most consistent? What about this magical lake effect and the legendary storms it produces? All of these questions, myths and legends are thoroughly investigated, exposed, explained and/or debunked in the new book, "Secrets of the Greatest Snow on Earth" by Jim Steenburgh. Jim is a Professor of Atmospheric Sciences at the University of Utah, and an avid Utah backcountry and resort skier and he has spent the last 30 years or so forecasting, predicting, studying, teaching, and recreating in the Wasatch Mountains and other abundantly snowy mountain ranges around the world.

In order to decide if Utah truly has the "Greatest Snow on Earth" one must first define exactly what that is and where the term came from. A brief history lesson in the marketing of Utah snow and how the phrase came to be is a great introduction to Utah snow and skiing. He begins by describing the various factors that contribute to great skiing and riding, from depth to water content, wind, storm patterns, breaking each down into the perfect storm of conditions he calls the "Goldilocks" storm, not too much, not too little, just right.

Once the parameters are defined, Jim takes the reader on a mountain weather journey, beginning with the complexities of the Wasatch microclimates and how each has specific orographic influence based on storm position and direction, illustrating the favorable flows for the major resorts and the areas most popular backcountry destinations. From there we are whisked around the world to look at how the weather affects many other popular snow destinations, from Colorado to New Zealand, the Andes to Japan's Hokkaido Island (which, he states, may be Utah's biggest contender for the crown of "Greatest Snow on Earth").

Despite the book's title, he goes beyond the boundaries of the Wasatch and provides a wealth of information on snow formation and weather basics that apply everywhere it snows in the mountains, from an in-depth look at snow formation in the atmosphere to a brief explanation of how resort snowmaking works. Atmospheric snow formation is broken down into Mother Nature's five-step plan, providing ample science to keep even the most diehard closet meteorologist engaged but keeping it simple enough for the weekend warrior or ski bum to follow along.



Secrets of the Greatest Snow on Earth
Jim Steenburgh
ISBN: 978-0-87421-950-0
Published by Utah State University Press

No book on Wasatch snow could be complete without an in-depth look into the infamous Utah "Lake Effect". Jim explores the real science behind what makes the Great Salt Lake contribute to the winter weather of the Wasatch, the overuse and abuse of the term by locals and TV meteorologists and debunks three common misconceptions about how and why the Great Salt Lake contributes to Wasatch snowfall.

My favorite chapter is titled, "Alta goes to War" and includes some great history of the development of the avalanche mitigation programs in Little Cottonwood Canyon. He includes a brief history of the early mining days at Alta and the challenges snow and avalanches presented to the town during its short-lived mining boom that faded away and gave rise to the ski resort of Alta in 1938. Homage to the early pioneers and icons of our industry, Monty Atwater and Ed LaChapelle, and their efforts to understand snow and avalanches in this amazing laboratory are still the building blocks of most mitigation programs today. He discusses current forecasting and mitigation methods and challenges of keeping Highway 210 open and safe for motorists passing under fifty slide paths on their way from Salt Lake to Alta each day. Jim explores the impacts of a growing city with more people than ever before enjoying the Wasatch mountains in winter. Some of the specific future challenges that he explores include the questions surrounding long term use of military weapons in such a densely populated area; alternatives include the possibilities of road realignment, snow sheds and tunnels and more Gazex in or near Wilderness areas. Utah has some tough decisions to make in the not too distant future and Jim does a great job objectively presenting the situation, and its possible outcomes.

He introduces avalanche basics following the familiar snowpack, weather and terrain framework, some discussion on danger ratings and hazard assessment are included but the chapter focuses primarily on human factors, particularly those involved in a number of accidents involving resort skiers and riders leaving the boundaries of various Utah resorts, examining the pitfalls of easily accessed " slack or sidecountry" skiing and riding and the consequences of "beyond the ropes" without the proper knowledge and tools.

Weather forecasting is covered next. For those who want their weather forecasts handed to them on a plate, Jim suggests a number of quality Internet resources from a variety of "professional weather guessers." He then gives you a high-speed, low drag crash course in mountain weather forecasting. He gives pointers on how radar works, what to look for in a satellite or radar images, how to read a current surface conditions chart, what to look for in a mountain weather station and provides a method for making all of this info make sense. He then delves into which forecast models are useful for what and how to interpret the information they provide. Primers are provided for those wishing to better understand how to generate their own forecasts.

Jim closes the book with a frank discussion on climate change and how it is already impacting the ski industry in Utah. He looks at rises in average temperatures, changes in storm tracks and patterns and what it holds for the future. A discussion of dust on snow events and how they impact the snowpack is included as well.

Does Jim unlock the Secrets of the Greatest Snow on Earth? Well, as we all know snow quality is often in the eye of the beholder, one skier's perfect powder day is another's mediocre day in the hills. He does offer a very comprehensive, easy to read primer on mountain weather and the unique factors that come together to produce those magical Alta storms that legendary memories and photographs are made from. I think this book is a great read for any ski enthusiast, avalanche students wanting to learn and understand more about weather than is covered in a Level 1 course, or the ski area forecaster looking to strengthen their personal skill set.

Jake is a Lead Instructor for the American Avalanche Institute, CI Rep to the AAA and retired ski patroller and avalanche dog guy. He is looking forward to the transition from a lack of powder season to sandstone and red dirt season. ❄

ABSURDUARY:

A look at Crested Butte's extremely warm and dry start to 2015

By Zach Guy

February 12, 2015: In the past few weeks, I've seen streams emerge from high elevation basins, sunny slopes melt back to complete dirt, and a migration of locals towards the desert for mountain biking or sun bathing. I've only lived in Crested Butte for four years, but this pattern seems so absurd for a high Rockies mountain town at 9,000 feet in elevation. I dug into some historical weather data to see how unusual this weather has been.

Since the New Year, we've been plagued by both snowfall drought and unseasonably warm temperatures. The temperatures have been the greatest anomaly this winter. Billy Barr in nearby Gothic has an exceptional record of temperatures and snowfall dating back to 1974 (www.gothicwx.org). As of Thursday, February 12th, 17 out of our 43 days this year have seen record-breaking high temperatures. There have only been two days in February that didn't break a temperature record, and we are currently going on eight days in a row of record high temps. I expect the next two days will break records too. On February 6, the temperature hit 52 degrees F, which was a full month earlier than we've ever seen temps reach into the 50s. I think my brother in Florida is having a colder winter right now.

Snowfall droughts this time of year aren't quite as unusual as the temperatures we've seen. I looked at both Gothic snowfall and records from the town of Crested Butte, which date back to 1962. (http://www.crestedbutte-co.gov) In Crested Butte, where the average snowfall in January is 41.6", we got 10.6" of snow last month. There have only been four other Januarys that saw less snowfall in the past 52 years. February is off to a rough start as well, with only a few inches. If it makes you feel any better, the winter of '76-'77 only saw a total of 3" of snow from December through February in Crested Butte. It's a shame they didn't have fat bikes back then.

As someone who loves the winter, I couldn't help but feel gloomy over the past couple months about what direction our winters are headed. We've all seen the research on how global climate change will affect the ski industry in the upcoming decades, but this winter has been a real slap in the face. It is sort of like reading an avalanche advisory from some nerdy forecaster who rambles on and on and on every day about persistent slabs (and there are always some naysayers, too) but one day, WHAMO! your whole slope rips out on you. It's a different experience when you come face to face with it, isn't it?

Looking towards Red Lady Bowl and some dirt slopes down lower. Last year on this date, I dug a pit on a similar slope as that dirt slope in the foreground and found a two-meter deep snowpack. *Photo by Zach Guy*

Here's to a colder, snowier spring for everyone except Boston. They've had enough already.

Zach Guy is the lead forecaster at the Crested Butte Avalanche Center and assistant snow safety director for Irwin cat skiing. His favorite ice cream is double fudge brownie.