34.3
FEBRUARY 2016

THE AVALANCHE REVIEW

Come, let's go
snow-viewing
till we're buried.

BASHŌ

WINTER RAVEN BY SUSAN X. BILLINGS

MOUNT WILSON

THE AVALANCHE REVIEW

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.

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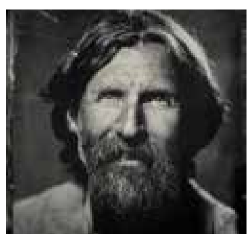
Doug Braumberger lives in Park City, Utah, and spends his winters ski patrolling for Deer Valley Resort and traveling around the backcountry in mountains of Utah. He has enjoyed setting skin tracks and making turns in Northern British Columbia, the Canadian Rockies, the Tetons, and other peaks throughout North America. When not skiing you'll find him riding bikes, climbing, or hiking with the dogs and with his wife Linda.

Sean Zimmerman-Wall spends his winters in Little Cottonwood as a Snowbird ski patroller, backcountry ski guide, and AIARE avalanche instructor. Each summer he travels to the wind-swept peaks of Argentina, where he co-owns Patagonia Ski Tours, a small adventure travel and tourism company. This winter, Sean prepares for his biggest challenge yet, fatherhood.

Ned Bair worked as a ski patroller on Mammoth Mountain for seven years. He is currently an Assistant Researcher at The University of California - Santa Barbara and works on avalanche research when he can. His wife Meghan and he have two children, Mason and Chloe. He is amazed how much he has aged, in good and bad ways, since they were born.

Bill Anderson is a full time guide living in Jackson, Wyoming. He is certified by the AMGA and an IFMGA member (but please don't hold that against him). As an instructor for both the American Avalanche Institute and Exum Mountain Guides, he spends a lot of time attempting to make the art of understanding snow and avalanches a little more attainable to skiers and riders.



Drew Hardesty been a forecaster at the UAC since 1999 and has come to love Excel spreadsheets. He says it's no coincidence that he's been reading the canon of some of the great Russian novelists this winter.

Nancy Pfeiffer has been an avalanche educator and forecaster for almost thirty years. She has been an avid skier all her life.

FROM THE EDITOR

BY LYNNE WOLFE

Welcome to the February issue of *The Avalanche Review*, an arts and science-themed production.

On the science side, you'll find stories and reports from all of the regional continuing education workshops, fondly known as the SAW circuit. Every piece I read piqued my curiosity, and I was grateful to each reporter for not just telling me who gave what presentation, but also for explaining the crucial points and take-home lessons. There's a lot of food for thought in these stories; if a sentence makes you want to know more, let me know and I can pursue the topic for *TAR*.

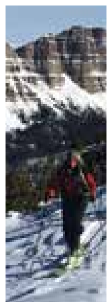
Along those lines, we also have reports from students and researchers who have benefitted from AAA grants. Have a look at the brains and experience we are investing our AAA funds in: impressive!

Other mini-themes include a couple of articles that bring us up-to-date in the first aid realm: "Still Not Dead Yet," from Terry O'Connor, Alicia Peterson, and AJ Wheeler, page 40, addresses new ICAR resuscitation guidelines, and on page 38, Martin Radwin examines trauma data and recommendations. The April *TAR* will add dimension to both of these topics with a piece from rescue specialist Dale Atkins.

Another theme in the issue looks at new fracture and collapse theory for the practitioner. Last summer I noted that Ned Bair had presented on this topic at a California continuing education workshop and followed up on it with Ned as it seemed to be a good fit for . When Ned's article came in, I ran it by a few folks at his level of understanding and research. Ned was patient and professional upon receiving generous and pointed input from retired avalanche specialist Ron Perla, of Canmore, Alberta, Karl Birkeland of the NAC, and from Johan Gaume of the SLF. His final product is pithy and understandable. I also managed to persuade Bill Anderson of the American Avalanche Institute to put his distinctive fracture mechanics class onto paper; can you imagine being in the field with him, mixing theory into practice as you tour along? Check them out, beginning on page 32.

Drew Hardesty uses years of Utah data to combine art and science in painting a clear picture of avalanche victims of the past. Perhaps some of his insight can inform current users to not become statistics themselves. He gives us even more reason to reach out to young men on skis or sleds who prefer steep NE-facing, high-elevation terrain in the sidecountry, when there is a rating of Considerable and a persistent slab problem.

On the art side of things, once I perused the Mountain Masters chapbook, I knew we needed some of Susan X Billings' work to grace *TAR*. You'll also find a range of incredible photos. Thanks Doug Braumberger, Grant Gunderson, and Ryan Dunfee. To my other generous contributing photographers — I ran out of room; we'll use more of your incredible avalanche and scenery shots in the April *TAR*.



Our featured Crown Profile, a case study from Terrace, British Columbia, was driven by Doug Braumberger of Park City, Utah. Knowledge of the people and the terrain powered his desire to delve deeper into an incident that could have been tragic, but good results brought important insights not just for the locals.

It's been a snowy winter so far; I'm thinking about risk and culture, trying to choose terrain to match the real conditions out there. The April *TAR* issue will delve into this kind of decision-making. I'd love to hear what you are thinking about in those terms. ▲

tinder for mentors

We are jumping on the coattails of the fabulous December issue of *The Avalanche Review* focusing on mentorship. We hope that while your interest is piqued that you will help us delve into how workplace mentorship relationships are formed and function. Look for a mentorship survey in your inbox soon. Thank you for your help with our project!

—Eeva Latosuo, Aleph Johnston-Bloom, and Lynne Wolfe

CORRECTIONS FOR TAR 34.2:

From Ron Perla (December 2015):

Ron didn't take the pg. 20 photo, it was in his USFS files, photographer unknown. Does anyone know who captured that classic image?

He reports that he did take that photo of Liam on page 22.

Caption correction:

Contrary to the prior caption, Lisa Issenberg did not go to Prescott College. She earned a Master of Industrial Design degree from Pratt Institute in 2001 and holds a Bachelor of Arts degree from Tufts University. *The Avalanche Review* regrets the error.

SWAG REVISION PLANNED FOR SUMMER 2016

The AAA is in the nascent stages of planning for the second revision of Snow, Weather, and Avalanches: Observational Guidelines for Avalanche Programs in the United States (SWAG). This third edition of the SWAG will be published in the early fall for distribution in preparation for the 2016/17 winter season. The last revision of the manual was in 2010.

The AAA will be hiring a SWAG Project Coordinator/Co-Editor to help execute the revision process. The project coordinator will work closely with Ethan Greene, CAIC Director and current editor of SWAG. Applications will be accepted through late winter. Look for further details about the position and applying for this role on avalanche.org.

Additionally, Ethan and the AAA will be working to comprise an Observational Standards Committee in the coming months to advise the Project Coordinator and help collate revisions for this edition. If you're interested in being involved in the SWAG revision process and/or have questions or suggestions on revisions please email aaa.swageditor@gmail.com.

FROM THE EXECUTIVE DIRECTOR

BY JAIME MUSNICKI

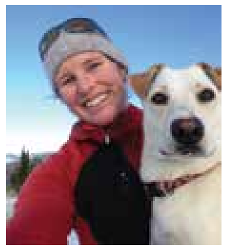
Greetings AAA members, supporters, and friends,

Happy 2016 to all of you. I do hope people's years are off to good starts… and that we're all experiencing prolific powder, regardless of El Niño's predicted effects in your area!

First, I'd like to congratulate and recognize Dallas Glass who has just stepped into the permanent role of Pro Training Coordinator for the AAA. We had an extremely strong pool of applicants for this position and learned a good deal through the interview process that will inevitably help the program moving forward. A huge THANK YOU to all the applicants who engaged with us in this process, and to Halsted Morris, AAA Vice President, and Kirk Bachman, AAA Education Committee Chair, who joined me as the hiring committee.

The AAA continues to chug along this winter. We're extremely pleased with the response we've been getting to the array of changes that have happened at the AAA recently. From this beautiful new *TAR* format to our new logo and website to the progress we've made with the Pro/Rec Project in the last year. It seems like I write this every time, but we've been BUSY! It is rewarding to start to see some of the fruits of our labors over the past couple of years. It really feels like the AAA has been stepping up within the snow and avalanche industry in a big way recently, and we're certainly excited to continue that trend this season and beyond. Ultimately, we're here to serve and support you, avalanche professionals across the United States (and sometimes even beyond).

As I write this, I am also thinking about a number of big questions whose answers are still unclear and puzzle pieces that we're still working to find and fit into place. From the roll out of the Pro/Rec Project to internal work and restructuring to help us become a more effective organization to trying to develop a fundraising program to sustain the AAA into the future, we're also sitting with a significant amount of uncertainty right now. It feels similar to skiing around the Tetons these days, deep slab problem still lurking. There is uncertainty and it feels unsettling… and yet it is also inescapable and just one piece of the whole experience and big picture. I think I have been improving my ability to be okay with the various uncertainties in my role of running the AAA, making decisions and continuing to help move the AAA forward with adequate respect for uncertainty, yet not becoming paralyzed by it. I hope that I can also say the same for my decision-making with the deep slab problem!



So, stay tuned for what's next with the AAA. We're in a very dynamic phase, which is exciting even as it is also uncomfortable at times. All of the changes underway are moving us in a direction of increased professionalism and support services for the avalanche industry and the people engaged with it.

As always, please feel free to be in touch directly with questions, thoughts, and/or concerns. Here's to a safe and fruitful continuation of the 2015/16 winter season. ▲

DECEMBER 2015: A RECAP

STORY AND PHOTOS BY JOHN STIMBERIS

El Niño: for some it means more snow, for others less. In the PNW we are looking at warmer and drier conditions, but not until after the new year begins say the climatologists. By the start of December we had recorded a scant amount of snow on Snoqualmie Pass, but lots of rain. 30" of rain and only a few inches of SWE had been recorded. In fact we had received a mere 14.5" of snow or 27% normal. Were we in for a repeat of 2014-2015? Will this be another record low snowfall winter?

The first week of December delivered a meter of snow and then it rained big time. But that's life in the PNW. Big snow followed by big rain followed by cooling temps and some dust on crust. But now the forecasters were telling us something we hadn't heard in a while. It was going to snow and it looked like it might keep on going. 17 of the next 18 days saw new snow. Snow levels stayed low and hopes remained high. The days and storms and avalanche missions blended together. One 7-day period saw 284cm (112") of snow. The power was out for days and the highway was closed quite a bit with avalanche missions, excessive snow, and bad drivers. We all feared the inevitable rain, but it never happened!

When the storm cleared it was time to add up the numbers. That 7-day period with 112" of snowfall was indeed a record, besting a 7-day 102" session from 1990. The monthly total also set a new record. We came in at 193.3", topping the previous best of 192" (December 1968). We were just happy to get snow and then to receive more in a week than we did in eight months last year, well heck yeah! It's exciting to be part of a record, especially one with lots of snow. But most of all it didn't rain (yet), it hasn't rained (yet), and we are skiing powder for days to come! Happy New Year and enjoy that El Niño when it comes to your local mountain. ▲

This tank is located on Snoqualmie Pass and is used to control slopes on Granite Mountain and Denny Mountain.

Above: A grader on Snoqualmie Pass with Guye Peak in view.
Below: McClellan Butte.

WHAT'S GOING ON AT THE NAC?

BY SIMON TRAUTMAN

The National Avalanche Center (NAC) was established in 1989 and formally recognized and funded by the US Forest Service (USFS) in 1999. Our mandate is to provide program guidance to Forest Service avalanche centers and military artillery programs at Forest Service permitted ski areas. We also strive to transfer new and useful technologies and research to field operations and practitioners.

Currently we are focusing a great deal of our energy on our avalanche center program. As many of you know, there are quite a few in the US. The US Forest Service and affiliated non-profits currently operate 12, the State of Colorado runs a large and comprehensive operation, and there are five or six fully independent non-profit centers … depending on how you count, the total is ~20!

As such, the ins-and-outs of how these groups interact and co-exist can be quite a puzzle, and our goal is to solidify the foundations of the piece belonging to the USFS.

In December 2015 we finalized the content of USFS policy relating to avalanche centers. This document was created with the help and input of all of our avalanche center directors, and is meant to formalize and define the existence of avalanche work within the USFS. It defines avalanche center types, sets guidelines for starting a USFS avalanche center, outlines a career ladder for avalanche specialists, and encourages cooperation with non-profit entities with similar missions.

We hope to be able to distribute copies of the policy document to interested parties in early 2016.

Our next step will be to develop a new and comprehensive set of Avalanche Center Guidelines. Just as we use policy to define 'why do we do what we do?' we plan to use guidelines to define 'how do we do what we do?' In other words, we are creating a living document that will define a series of best practices pertaining to avalanche center operations.

This work will be done with assistance and input from avalanche centers across the US, and if the stars align, the first iteration of the Avalanche Center Guidelines will be completed and available in the fall of 2016.

Good luck this winter and drop me an email if you want more information!
strautman@fs.fed.us ▲

Field Obs

Chiver's Ridge off Teton Pass shows off a glimmering coast of fresh at dawn.
Photos Ryan Dunfee

WHAT'S NEW WITH WYDOT?

BY BRIAN GORSAGE AND JAMIE YOUNT

This past summer the WYDOT avalanche office upgraded two of the oldest Gazex exploders on Teton Pass and added to their avalanche mitigation infrastructure with an O'bellx gas exploder in Hoback Canyon. WYDOT has operated the Gazex system since 1992, and after 22 years of service the two oldest Gazex exploders on Teton Pass were in need of an update. Lead Forecaster Jamie Yount and Avalanche Technician Brian Gorsage retro fit the Twin Slide and Glory Bowl with two new 1.5m³ Inertia exploders from TAS of France. The project was done in-house, saving the State of Wyoming $100,000 in construction costs. Total cost for the project was $178,500 with $50,000 in installation costs, most of which was helicopter time.

The project was started in late April 2015. The WYDOT avalanche office took advantage of a Kmax helicopter working in the area to remove the old exploders; this helped reduce the cost of bringing a capable helicopter to Jackson. After 22 years the old anchor bolts were rusted firmly in place. A full day's effort was spent trying to remove them by hand and not getting a single one to budge. The next day a cutting torch was flown onsite with a helicopter to remove the bolts. After the exploders were flown off the mountain, tools and materials were staged for the construction of large concrete footers to support the counter weight for the new Inertia Gazex exploders. The counterweight is a massive 3000lbs steel cylinder that acts as a recoil mechanism during detonation and greatly reduces the wear on the exploder components. New tanks and valves were also staged at the central gas shelter to upgrade the aging gas storage infrastructure. In late June the crew poured five yards of concrete at the Glory Bowl location and six yards at the Twin Slide. The concrete was allowed to cured for 28 days. While the concrete cured, the new tanks and valves were installed in the central gas shelter. The counterweights and exploders were rigged to fly and the tools, materials, and 2000 lb compressor were then staged into the Hoback Canyon for the O'bellx project. In late July, with another Kmax helicopter, the counterweights and exploders were flown on to their foundations and anchored to their tie backs. The crew then hiked back down to Teton Pass, drove 40 miles to Hoback Canyon, and hiked up the Calf of the Woods slide path to stage the tools and materials for the O'bellx project. The next day the counterweights were pinned to the exploder tubes and gas lines were connected and pressure tested. The final step in the construction of the Inertia type exploders was to drill a two-inch hole 15 inches deep into the concrete and epoxy in the counterweight guide pin. The system was successfully test fired in early September.

The second project of the summer would be to install an O'bellx in the Calf of the Woods slide path in the Hoback Canyon. This would be the second unit installed in North America with first being in the Cow of the Woods slide path which is the adjacent path to the north. Install was also done by the WYDOT avalanche office, saving the State of Wyoming $50,000 in construction costs. The O'bellx is designed for smaller starting zones that are difficult to access during the winter months and the Cow and the Calf have that in spades. An additional advantage of O'bellx technology is that it can be deployed and retrieved with a helicopter without personnel onsite. An ideal technology for the terrain in Hoback Canyon where the starting zones are not accessible in winter.

The O'bellx install involved fewer steps and was completed in five days compared to more than two months of work on the Gazex retrofit. After a geotechnical investigation, a drilled rock footer was selected as strongest and most cost effective install. Fortunately the drilling went well with each hole taking 30-45 minutes. The concrete footer consisted of four anchor bars drilled and epoxied into six feet of rock. Fifteen 80-lb bags of concrete were then mixed and poured by hand for a small leveling pad to support the O'bellx tower. With all the wildfire activity across the western U.S., securing a helicopter capable of lifting 2200 lbs. became a bit of a chess match. With one day left on the United States Forest Service permit for helicopter operations, the tower was installed with a 1m extension and the O'bellx was flown into place and successfully test fired. Equipment cost were $142,500 with an additional $25,000 in installation costs.

WYDOT continues to make large investments in avalanche mitigation infrastructure with the goal of maintaining a safer and more efficient transportation system. ▲

Kmax setting exploder.
Photo Bradly J. Boner

Drilling anchor bolts for O'bellx. (Surprisingly not the worst task we had.)
Photo Brian Gorsage

The O'bellx with a one-meter extension.
Photo Brian Gorsage

Brian Gorsage is currently a WYDOT Avalanche Tech. Previously, he's worked three years as Avalanche Forecaster with ITD and seven years ski patrolling at Snowbird. Loves pushing the button and dislikes east wind.

Jamie Yount is an Avalanche Technician with the Wyoming Department of Transportation, a member of Teton County Search and Rescue, and the president of the Avalanche Artillery Users of North America Committee. Jamie makes a mean breakfast burrito, is excellent at parallel parking, and underestimates everything (especially Gazex projects).

METAMORPHISM

JIM KENNEDY RETIRES

BY RYAN HUTCHINS AND BROOKE EDWARDS

Jim Kennedy in his element.
Photo Heather Thamm

The two words utilized most in the retirement party celebration speeches of Jim Kennedy's 35 years at Alyeska Resort were "Lucky" and "Good". The evening was a surprise event for Jim and to kick off the night's festivities, Alyeska's General Manager, Di Whitney invited many of his colleagues to the stage to do a "roast." The interesting thing was that not a single person who took the stage to share old slides, stories and memories had one "roasting" comment to say about Kennedy. The theme instead was one of deep reverence and respect from all in the audience.

Dave Hamre, who served as snow safety director prior to Kennedy, stepped on the stage and did some complicated math as to how many skiers passed under the watch of Jim during his 27 years of being in the "hot seat" as snow safety director at Alyeska.

To have no one die on his watch, folks marveled, spoke to just how good (and lucky) Jim Kennedy was at his job.

Alyeska Resort is one of the most complicated ski resorts in the country to manage. Though it is small in acreage, its terrain is massive with all the biggest starting zones looming large above the entire resort. With this much overhead hazard to begin with, it takes three howitzers and a very talented snow safety and patrol staff under the guidance of deep knowledge to make crucial decision on a day-to-day basis.

When I asked long time snow safety specialist Dave Marshall what he thought of that assessment, he remarked that the word "lucky" tends to detract from the skill of someone. " No avalanche fatalities on his watch for 27 years is not luck, it's immeasurable instinct, skill and dedication. People get lucky occasionally, but what Jim Kennedy did in managing a Class A avalanche resort for so long with no major incidents is absolutely remarkable" replied Marshall.

Dave began his career at Alyeska Resort in 1980 as a ski racing coach and later become an Avalanche Technician in 1982. Recalls Marshall of Kennedy's beginnings: "He started as a kid from Sandpoint, Idaho who moved to Alyeska Ski Resort and worked for the lift crew while living in his truck. He rapidly transitioned to the Pro Patrol, eventually taking over as Snow Safety Director and became one of the most respected leaders the avalanche community has ever seen. I've never been prouder of any friend with what they have accomplished."

Dave Hamre, the original snow safety director of Alyeska Resort who later went on to become the Avalanche Program Manager at the Alaska Railroad Corporation, shared this story as one of his favorite memories of Kennedy:

"I remember one time about 8 or 10 years ago when we actually got snow that I was tied up with some important meetings at a time when we really needed to shoot. I asked Jim to pinch hit for me as the guest gunner. So while I was off in left field Jim pulled the trigger on the Peterson slide knocking out a wall-to-wall 12-footer. That slide ran about 3,600 ft. vertical before it hit the lake, breaking out the 2' thick ice and shoving it across our tracks and the road into Turnagain Arm. Unfortunately it also rolled over a big hunk of the railroad tracks. About an hour later I crossed paths with Jim as he was headed back to the resort and was getting out of my meeting. He didn't really say what the results were other than something like, "have fun with the cleanup". Two days later we were still 'having fun with the cleanup'."

Reid Bahnson followed Hamre and served as the snow safety director prior to Kennedy. Says Bahnson of his choice of replacement:

"As the snow safety director there in 1989 when I left that position, I strongly recommended to Alyeska's managers an unlikely "wild young ski patroller" (Jim) to take over the snow safety director job. Upon my departure, I wanted someone who "knew snow" and was not afraid to say no when needed to take on the challenge of keeping Alyeska avalanche safe and of eventually opening Alyeska's North Face; 2500 vertical feet of double black diamond complex avalanche terrain that spans a couple of climate zones from near sea level to arctic alpine. Those managers acquiesced, reluctantly, and the results over nearly the last three decades speak for themselves:

- **14,978 avalanches** class 2 or larger
- **2,288 days** with the North Face open
- **27 years** in the snow safety hot seat
- **0 skier/rider** avalanche deaths or injuries

Jim Kennedy knows snow and every ski resort with significant avalanche hazards should be so fortunate as to have their own wild young patroller waiting in the wings ready to take over the hot seat."

Kennedy was truly surprised by his surprise retirement party and is still so moved by the overwhelming turnout at the event. "It was so cool to be up there, taking a walk down memory lane with so many of my great old buddies; a guy couldn't ask for anything better", remarked Jim.

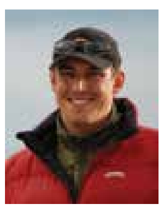
He's already transitioned to his new job at the Alaska D.O.T. and of course has jumped right into the fire with two feet managing a road closure due to an avalanche closing a popular backcountry recreation area, Hatcher Pass, to the north of Anchorage. When asked if he had any words of advice for Scott Hilliard who is filling his big ski boots as the new Snow Safety Director at Alyeska Resort, Kennedy commented: "Hilliard and I have been tossing an old quote back and forth during the transition from one of the Jackson Hole old guard in Snow Safety: Larry Livengood. The quote? "What has happened before will happen again. Then there's the shit we haven't seen before!" Wise words Larry.

A mentoring ground under Kennedy created a learning environment which has benefited the entire state of Alaska as he produced a pipeline of knowledgeable avalanche workers to the Alaskan Department of Transportation ,The Alaskan Railroad , Chugach Powder Guides, the Alaska Avalanche School and the Chugach National Forest Avalanche Information Center. With legends like himself and Dave Marshall continuing their presence on the slopes as Snow Safety part-timers, Alyeska Resort will continue to benefit greatly from the history that continues to mentor and grow an ever-increasing knowledge base amongst Alyeska patrol.

May we all raise a grateful glass to honor Jim Kennedy, one of the most accomplished Avalanche forecasters in the industry. Thanks for keeping us safe all these years Kennedy!

ADDENDUM: As of this writing on Jim's first week at his new job with Alaska's D.O.T. Avalanche program he got to deal with an unusually large "ten year" early season avalanche cycle that closed and threatened roads in the Talkeetna Mountains and the Alaska Range. New challenges for an experienced hand. ▲

Ryan Hutchins-Cabibi is a pro patroller at Alyeska Resort, and an avalanche educator who spent over a decade teaching winter and avalanche courses for NOLS. When the snow melts Ryan rides his downhill bike as a Bike Patroller or is behind a sewing machine; building, modifying and repairing outdoor gear as the owner of Corvus Threadworks in Girdwood Alaska.



Brooke Edwards has spent a lifetime as a freelance writer and poet, but in her two decades in Alaska she has also been engaged in the avalanche community as a board member for F-CNFAIC, an avalanche observer, a NOLS instructor, an instructor for Alaska Avalanche School, a ski instructor at Alyeska Resort, and working on staff for Chugach Powder Guides.

THINGS I'VE LEARNED WORKING WITH JIM KENNEDY

BY SCOTT HILLIARD (NEW PATROL DIRECTOR AT ALYESKA)

"Think big … and act accordingly."

"Two inches of water is a good time to shoot."

"Rounds good, squares bad."

"Frozen good, melting bad."

"Mother Nature is always in charge."

"Every year there's something we've never seen before."

"A plan is just a point to deviate from."

"I'll never ask you to do what I won't do myself."

"Rule #1: never f-up above a cliff!"

"Damn cornice (or glide-cracks, or roof-slides, or snowmakers)."

"If it'll move, make it so. Take it to the dirt!"

"Don't over-think it."

"Don't miss the window."

"Don't do it if you're not comfortable."

"I told them not to put that there."

"With all this data and forecasting, the best thing is to just get up there and feel it!"

"The best way to deal with the spring meltdown is to get out of the way. The end of April's a good time to be on a golf course!"

"Just tell them 'No!' – you can always say yes later."

"There's NO, F-NO, and Don't Ever Ask Me That Again!"

"It'll be at least an hour, maybe less."

"Never happened, and never will again."

"That's only a Class 2 (Howie Class 4)."

(If he stole some of these, credit properly goes to Onslow, Bahnson, Hamre, and others)

ESAC

The Eastern Sierra Avalanche Center is excited to announce the hiring of two Avalanche Forecaster positions for the 2015-2016 winter season. Doug Lewis has accepted the role as Lead Avalanche Forecaster and Josh Feinberg will join him as Avalanche Forecaster.

As for operational side of things, ESAC is essentially operating as a Type IV Center this year, issuing Snowpack Summaries three to four times per week via two forecasters. We began operating on December 1, and will run through mid-April.

One of the biggest pushes that the Center is making for this year is a community engagement piece. We are not only looking to improve/expand our education and outreach program this year, but looking to more effectively get observations from the public and encourage discussion around Conditions and snowpack.

Doug Lewis has 17 years of avalanche forecasting and snow safety experience, having worked in the Manti-La Sal National Forest (Moab, Utah), Chile, New Zealand, Colorado, Montana, and Alaska in both the heli-ski business and for the Alaska Department of Transportation. He is a qualified trainer and educator with strong public engagement experience and has worked closely with a number of government and NGOs to develop collaborative programs. Doug has experience in automated weather systems, a variety of technologies applicable to snow safety, and strong organizational and management experience.

Josh Feinberg has worked as a professional ski patroller for Mammoth Mountain Ski Area since 2002, and served in a supporting avalanche forecaster role from 2009 - 2011. Josh has formal professional training through the National Avalanche School, American Institute for Avalanche Research and Education (AIARE, Level III) and the Professional Avalanche Workers School (PAWS). Josh has extensive knowledge of the terrain and conditions of the Eastern Sierra, a strong connection to the local backcountry community, and considerable skill in public speaking and community engagement.

CNFAIC

Congratulations to Wendy Wagner upon securing the permanent Director slot at the Chugach NF Avalanche Info Center (CNFAIC)! Wendy stepped in as interim Director last season after four seasons working as an avalanche specialist and lead forecaster. The Alaskan snow and avalanche community is very excited that she's now in this leadership role, effectively steering the ship!

Dear Fitz (John "Fitz" Fitzgerald),

It was a sad day for the CNFAIC last summer when you called to say it was time to leave the Chugach National Forest Avalanche Center. You were with us for three seasons and left your mark! Because of your mentorship, we not only have weekly stability meetings, but we have a rescue sled in the field vehicle, staff and public rescue sessions outlined, internship program developed, and many many more behind the scenes actions that have led to the growth of the Center. Fitz, thank you for all the hard work, dedication and tireless hours you invested. But most of all, thank you for all the great times! You are already sorely missed by all of us in Alaska and we wish you (and Erin!) the very best of luck and happiness wherever your paths lead.

—Love, Wendy, Graham, and Heather.

Fitz, the powder ninja.
Photo Heather Thamm

2015 SNOW AND AVALANCHE WORKSHOP REPORTS

USAW

BY BRUCE TREMPER

The Utah Snow and Avalanche Workshop (USAW) was yet another smashing success with over 600 attendees and 29 commercial exhibits. Each year, USAW provides critical, continuing education for both professionals and the public with attendees and presenters from across the Intermountain West. Per tradition, the chief organizer and MC, Craig Gordon, sported his usual tuxedo and the energy that only he can deliver.

USAW featured presentations catered to professionals in the morning and talks for the public in the afternoon. See the descriptions and links below to view the public talks on-line.

To begin the professional sessions, Ethan Greene, Director of the Colorado Avalanche Information Center (CAIC), gave a spellbinding overview of an Avalauncher accident, as well as recent work done by CAIC and Colorado Department of Transportation to improve worker safety. It included a cool video of testing blast wall designs, which showed liquefied aluminum showering outward from the blast into the wall. This apparently occurs when a round explodes within the tube.

Matt Jeglum from the University of Utah Department of Atmospheric Sciences presented a talk entitled, "El Niño/La Niña- What it Means for Snow in Utah and Other Areas of the West." As usual, neither El Niño nor La Niña have any correlation to the climate of northern Utah, a detail that everyone seemingly needs to be reminded of annually. However, the usual El Niño pattern-dry to the north and wet to the south-will likely affect others in the West.

Brett Kobernik from the Utah Avalanche Center presented a simple API (application programmer interface) to display weather charts from everyone's local, automated weather stations.

Ian Reddell from Solitude spoke about how they adjusted avalanche terrain management strategies for our record-setting low snow winter last season and strategies we can all employ in the future if winters continue the warmer pattern.

Spencer Storm from Snowbird presented on their weather and data collection program in Mineral Basin and Mary Ellen Gulch, the later being an area in which they plan to expand in future years.

Marie Pate Taylor gave the talk: "Applying Smart Zoning in Avalanche Terrain," arguing that through zoning and smart land use practices, local authorities and private landowners can work together to reduce new construction in avalanche areas.

Brian Gorsage from the Wyoming Department of Transportation presented a talk on Gazex and O'bellx installation, "An Internal Installation of Progressive Avalanche Mitigation Systems." See page 7 of this *TAR* for an in-depth version of Brian's talk.

The amazing Doug Richmond, Patrol Director from Bridger Bowl in Bozeman, presented "Non-result Avalanche Control Events - Uncertainty and the Persistent Weak Layer in the Ski Area Operational Setting." Delivered with his characteristic, homespun vernacular and talent for explaining complex phenomena in simple ways, Doug did a fabulous job of reinforcing for the newbies that low probability and high consequence avalanches, such as deep persistent slabs and wet slabs, can be very tricky to forecast.

Finally, Tim Hendrickson with Mountain Guard delivered the presentation, "Litigation in the Ski Industry," highlighting the importance of avalanche mitigation documentation and how it is used during a claim.

The public sessions in the afternoon started with the Utah debut of our cool new update to the "Know Before You Go" avalanche video that we have been working on for the past year. We produced it in partnership with CAIC and Avalanche Canada. This video shows the potential for high budget, high production value videos for avalanche education. It has been getting huge numbers of views since its release. You can see it at https://vimeo.com/144545554.

Following the video, Craig Gordon spoke on the history of the KBYG program. Because of sound issues, I could not capture Craig's talk. Jamie Musnicki from the American Avalanche Association then educated us on the Education Levels Framework. You can view the video of Jamie's talk at: https://www.youtube.com/watch?v=rINikiK_yKE.

There was a lively panel discussion on "Social Contract- Trends in Backcountry Users and Their Level of Responsibility to Each Other," featuring Drew Hardesty of UAC, Steve Scheid of USFS, Laurie Delaney of UDOT, Jay Pistono, the Teton Pass Ambassador, and Jon Schofield of Dawn Patrol Skier/Splitboarder. You can watch it at: https://www.youtube.com/watch?v=CVJvZ3DZn_U.

The always popular speaker, Jim Steenburgh with the University Department of Utah Atmospheric Sciences, gave a talk called: "Climate Change and Variability: Snowy and Not So Snowy Projections for the 21st Century and the Winter of 2015–16. Cutting through the Hype and Taking a Look at What We Can and Can't Expect This Winter and in the Coming Decades." Jim gave a great overview of what to expect from our future winter weather. In short, higher temperatures, higher freezing levels, and shorter winter seasons. Low elevations will notice the change in snow amounts more dramatically than high elevation locations. You can watch this talk at: https://www.youtube.com/watch?v=pvXCS4WWEBE.

Avalanche victims David Brown and Mike Hales told their tale called: "Jaws Avalanche Accident Case Study, 12.24.2014. A Summary of the Christmas Eve Slide in Jaws, from Both the Victim and Rescuer's Perspective of the Events that Led up to the Avalanche, the Ride, Rescue Efforts, and Lessons Learned." You can view the video at: https://www.youtube.com/watch?v=x-U_a-7vBOnY.

Blase Reardon of CAIC gave a great human factors talk. The title says it all: "Magoo, Me, and You: Developing Expert Intuition in the Backcountry." Blase emphasized, "research shows that most of our decisions are unavoidably influenced or even determined by subconscious cognition. In the backcountry, this tendency often shows itself as heuristic errors or the illusion of skill. We can, however, develop expert intuition by relying on practices that increase feedback reliability and quality." You can view the video at: https://www.youtube.com/watch?v=1vmYVI-QJEE.

The well-known adventure athlete Brody Leven gave one of his characteristically entertaining talks in his signature, polished style: "Proceed with Caution: Traveling to Ski the World Without Avalanche Forecasts." The speech was subtitled, "while enticing to visit, most of the world's mountains don't have experts trying to keep you on top. Safely climbing and skiing objectives outside the forecast zones is possible. Brody Leven presents practical, real-world approaches to worldwide skiing." You can view the video of his talk at: https://www.youtube.com/watch?v=AI0yM3-YYag.

Finally, Bruce Tremper, the recently retired 29-year Director of the Utah Avalanche Center, delivered a retrospective of his near 40 years as a professional avalanche worker, presented a family tree of avalanche knowledge in North America, and described how being a 4th generation Montanan—on both sides of the family—has helped shape his life and career. You can see the video of his talk, "Forecasting Then, Now, and in the Future" at: https://www.youtube.com/watch?v=d0gwYqFVI0.

CSAW

BY IAN HOYER, AVALANCHE FORECASTER IN THE CAIC LEADVILLE OFFICE.

The Colorado Avalanche Information Center held the 14th annual Colorado Snow and Avalanche Workshop (CSAW) at the Riverwalk Center in Breckenridge, CO on October 9, 2015. It was a beautiful fall day and another year of strong attendance and riveting presentations. As always, it was a great way for Colorado avalanche professionals to learn, network, and start getting back in gear for the upcoming season.

Craig Gordon of the Utah Avalanche Center got the day rolling. His dynamic presentation focused on youth avalanche education in the US, and the North American roll out of the "Know Before You Go" program. We are excited to see this program take off in Colorado.

Scott Savage, director of the Sawtooth Avalanche Center, followed up with an interesting take on how memory can play tricks on us and the relevance of this to avalanche work. His presentation hit on a lot of points, one interesting take-home being that our brains can manufacture untrue memories. This means that we cannot always rely on firsthand testimony. Even smart people can remember things that never happened. His recommendation is to take pictures of anything interesting you see so that you have an unbiased record if you do need it later.

Simon Trautman of the National Avalanche Center talked about something rather special in our profession- the intersection of work and play. Our work can be enjoyable, and there is nothing wrong with that. However, Simon stressed the need to be careful. He boiled it all down to responsibility and professionalism. If you step outside the bounds of what you need to do to accomplish your job, you may hurt not only yourself, but potentially your family, employer, and even the profession as a whole.

Next up was Karl Birkeland, director of the National Avalanche Center. His presentation focused on slabs and weak layers. He performed a variety of Propagation Saw Tests to modify the blocks of snow in various ways, reaching interesting conclusions about the importance of slabs to propagation. To me, the biggest take-away was to be careful and meticulous while doing snowpack tests. He showed that surprisingly small modifications, easily replicated with shoddy craftsmanship, can change test results. If you are going to take the time to do snowpack tests, take the extra 30 seconds and do it right.

Dave Hamre of Alaska Railroad talked about research on fracture speeds, data that he first presented at ISSW last year in Banff. His presentation exemplified the ISSW motto, "a merging of theory and practice." Based on his experience triggering and watching avalanches, he thought that the avalanche fracture speeds that scientists present in theoretical models were too slow. He collected and analyzed videos of avalanches triggered by explosives and ended up with faster fracture speeds than most models predict. I think we should all take Dave's example as an inspiration; if you have an idea, or if something you hear at a conference strikes you the wrong way, take the effort to look into it more deeply, and then share your results with the community.

AAA board and staff at the AAA booth at CSAW: Left to right: AAA ethics co-chair Aleph Johnston-Bloom, ED Jaime Musnicki, and VP and Awards chair Halsted Morris.
Photo Bill Cotton

Pascal Haegeli of Simon Fraser University focused on the avalanche survival curve. He took a look to see if the holy chart that everyone shows from their avalanche classes actually applies outside of Switzerland (where the original data originates). Compared with the Swiss curve, his Canadian data showed a quicker drop at the early stages of burial and lower survival rates with prolonged burial. He hypothesized that these discrepancies may be due to differences in trauma, snow climate, and the availability of organized rescue. This decreased time frame made me think that you want to be even more confident in your rescue skills, as a victim's chances may start dropping precipitously even before you hit the 15-minute mark.

Joe Ramey from the National Weather Service finished out the morning with his annual prognosis for the winter. You can find a short recap of his presentation from Jed Porter on page 31 of *TAR* 34.2. After lunch, there was a focus on explosives. Tyler Weldon of CDOT came to tell us about experiments conducted by the AXPRO group at Colorado School of Mines. These experiments led to the development of the blast shield that CDOT now uses. Kevin Powell came all the way from the United Kingdom to bring us up to date on the DeltaLancer Avalauncher round. He went over design improvements and showed the results of a study looking at in-bore detonation events of avalauncher rounds.

John Stimberis of the Washington State DOT shared his experience with an avalanche incident that occurred while they were working to open Chinook Pass in the spring. A plow driver got hit by a slide and buried in his plow on the road. He went through the decision-making process and the nerve-wracking experience of ski cutting that avalanches that flowed over the plow (and driver) in order to make the scene safe to dig the driver out. See the cover of *TAR* 33.3 for a full treatment of this incident.

Pascal Haegeli came back to the stage to discuss the effectiveness of avalanche airbags. Companies have thrown around some spectacular numbers in marketing these devices; he decided to do his own analysis. Depending on the exact metrics, he found that avalanche airbags increase your safety margin by about half. That is impressive, but it is no silver bullet. Another big take home for me was to always wear your crotch strap! Without it, the airbag may keep you from being buried, only to strangle you in the process.

To finish off the day, Dave Hamre returned for the grand finale, a talk giving insights from his 40 years in the avalanche industry. He emphasized that every year you are going to be surprised. There is always something different, so be open to seeing how the situation in front of you is unique, rather than trying to make it fit into your idea of what you think is happening. Another point that really struck home was the idea of taking the long view when working in avalanche terrain- being 99% sure a slope won't slide is not nearly confident enough. Routinely exposing yourself to slopes with a 1 in 100 chance of sliding might work for a season or two, but eventually you are going to get bit. When looking at the accumulated risk over your whole career, you should really only expose yourself when you think there is less than something like a 1 in 10,000 chance that the slope will slide. The cumulative exposure over a lifetime of work is something to remember the next time you think you might be stepping close to the line.

Many thanks to all the presenters and sponsors that make this event possible. We look forward to seeing you next year!

CAW

BY DAVE REICHEL

In this season of the much-hyped Godzilla El Niño, pouring rain during the 2015 California Avalanche Workshop was fitting. About 160 folks attended this second annual event at the Lake Tahoe Community College Theater. The lobby featured tables representing the Sierra Avalanche Center, Mount Shasta Avalanche Center, Mammut, Avatech, AIARE, and the Nickolay Dodov Foundation.

David Page started the workshop off with a review of last year's Human Factor article and a teaser for Human Factor 2.0, which was officially released a little over a week later. Page's talk touched on many of the issues he explored in his worthy article.

Jon Rockwood followed with an intense account of the fatal 2012 avalanche accident in Ward Canyon. It is hard to imagine a more difficult tale to tell or a better telling than Jon's. The audience was in awe of the emotional courage it took to share this incredibly difficult story.

After a break, Zach Tolby from the National Weather Service in Reno provided an outstanding overview of El Niño. If anyone needs help producing a brilliant slideshow that explains science stuff to a theater full of skiers, riders, and snowmobilers, Zach is highly recommended.

With the geeky parts of our brains warmed up from the El Niño talk, Brint Markle from Avatech proceeded to blow away the three pinners in the audience with actual high-tech in the backcountry. The crowd appreciated the overview of Avatech's current and future offerings.

After lunch, we sped through an overview of the proposed Pro-Rec Split by Travis Feist. Ben Hatchett provided more weather geekery with a look at extreme weather events in the Northern Sierra. (See page 46 of this *TAR*.)

Jon Dove, with the Mt. Shasta Climbing Rangers and Mt. Shasta Avalanche Center, gave an overview of the avalanche concerns on Shasta. The ease of access, along with the huge avalanche paths, makes for a challenging situation on the dome.

The final speaker was pro snowboarder Kevin Jones, a nine-time X Games Medalist, two-time ESPN Rider of Year, three-time Snowboarder Magazine Snowboarder of the Year, who reflected on 25 years in avalanche country.

The workshops ended and folks migrated to the lobby to enjoy local Cold Water Brewery beer while socializing and discussing the day.

In the week following the California Avalanche Workshop, we sent out a survey and received valuable feedback. While there were plenty of useful and constructive suggestions, it was gratifying to see that 84% of attendees reported being very satisfied.

The largest grant (by far) that we received to put on the workshop was from the American Avalanche Association. The California Avalanche Workshop would not have been possible without this support. Thank you.

NRSAW

BY ERICH PEITZSCH

What do you get when you put an alpinist, a weather forecaster, an ex-pat living in Canada, a non-profit executive director, and a Kiwi in one room? The workshop formerly known as the Northern Rockies Avalanche Safety Workshop, of course. I say formerly because we've renamed it to Northern Rockies Snow and Avalanche Workshop (NRSAW) so we can be one of the SAWs instead of the ASW (doesn't quite have the same ring). The Friends of the Flathead Avalanche Center (FOFAC) organized the workshop this year and they would like to thank all of their supporters for this year's workshop including title sponsor TAS/Gazex and, of course, a professional development grant from the American Avalanche Association (AAA). I'd personally like to thank everyone involved in planning this event from FOFAC.

This year, there were about 175 attendees from the local region but also from north Idaho and Spokane, Washington. The audience was a good mix of professionals and recreationists as well as both motorized and non-motorized users.

First up in the morning, Grant Statham from Parks Canada (and of TEDx fame) gave another riveting presentation about risk management. Grant spoke about communicating hazard and risk (the overall general them of this year's workshop). He discussed the basics of hazard and risk, the target audiences, and key messages for communicating hazard and assessing risk (using avalanche problems as an example), and the need to maintain a clear but concise message for avalanche professionals.

Next, Dr, John Snook of the Colorado Avalanche Information Center spoke about recent advancements in weather model development and how both professionals and recreationists can use a suite of weather products for their decision-making process. He also discussed the uncertainty inherent in weather forecasting and how to communicate this uncertainty. Communicating this uncertainty enables users to understand the likelihood of any given weather event or avalanche problem.

Jaime Musnicki, Executive Director of the AAA, then gave a broad overview of the role of the AAA within the snow and avalanche industry and highlight recent changes at the AAA that are helping better serve their membership. She then focused specifically on the Pro/Rec Education Project and the details of the AAA Pro Training Program. She unveiled the new, sleek AAA video as well.

Grant Helgeson, senior forecaster with Avalanche Canada, waxed his mustache for the event and wooed the crowd with case studies illustrating risk and hazard assessment. Grant provided an entertaining presentation by engaging the crowd and illustrating how Avalanche Canada derives their weather products and avalanche advisories. Given our close proximity to the great white north, many backcountry users from northwest Montana venture north across the border, so it was very useful information.

The last speaker, Dr. Jordy Hendrikx, professor of Earth Sciences and Director of the Snow and Avalanche Laboratory at Montana State University, came back to Whitefish for another round of workshop goodness. He discussed his wildly popular backcountry tracks project, but framed it in the context of providing insight and understanding of risk. He discussed how the data from this project thus far show that tracks are often influenced by factors which include group size, gender, experience, and motivations rather than just snow stability and terrain. He emphasized the notion that by also being aware of these other factors we can reduce our chances of inadvertently making riskier decisions in the backcountry.

Finally, all speakers and Burlington Northern Santa Fe Railway (John F. Stevens Canyon) snow safety director Ted Steiner formed a panel at the end of the day. The discussion began with each speaker addressing the questions: How do we need to think about risk in the backcountry every time we head out and what professional and/or personal experiences have helped shape your approach to risk management? It was quite interesting to hear the varied experiences from each speaker and the unique situations that molded their approach to risk. There was great discussion and questions from the audience on topics of backcountry partner selection to assuming your own responsibility when traveling in the backcountry.

One of the most thought-provoking topics that rose to the top for me was the manner in which we, as professionals, handle uncertainty in the context of risk, and, subsequently, how we communicate that uncertainty to our audiences. First, uncertainty is inherent to some degree in our field, and we are all well aware of that. Yet there appear to be personalized approaches to dealing with increasing uncertainty. In terms of communicating uncertainty, it can be expressed in confidence intervals and exceedance probabilities (statistically speaking) or more qualitative by using terms like possible, likely, or very likely. Regardless, the message from this group of professionals to the general audience was the importance of recognizing uncertainty whether it's forecasting on the meso-scale or when recreating with friends, and not to let it paralyze your decision-making process.

Overall, it was a great success with rave reviews from attendees. The only downside was that 4 out of 5 speakers ended up at the wrong establishment for the after-workshop social. Apparently, there was a bit of uncertainty between the Great Northern Bar and Grill or Great Northern Brewing Company. Likely mistake??

NSAW: 9 THINGS I LEARNED

BY TYLER COHEN

A version of this story first appeared on backcountry-magazine.com.

In early November, 600 people packed into a conference room at Seattle's University of Washington for a full day of education and insight at the revamped Northwest Snow & Avalanche Workshop (NSAW). Organized and hosted this year by the Northwest Avalanche Center (NWAC), NSAW gathered 10 presenters, from guides and avalanche educators to paramedics and a behavioral psychologist, to discuss the latest in safety, science and decision making.

I was asked to participate on a panel titled "The Future of the Backcountry: Where Will We Be In 2025?" in which we talked telemark's death, cell-phone-free backcountry zones, drones that might predict slope stability and more.

Here are nine things I learned at the workshop.

1. Practice Often With Your Airbag

Pascal Haegeli, an Assistant Professor at Simon Fraser University in British Columbia, presented his findings on the effectiveness of avalanche airbags—and they're striking. In his research dataset, an airbag increased a user's chance of avalanche survival by 11 percent while eliminating half of fatal burials. "If a medical treatment got results like this, it would be flying off the shelves like hotcakes," Haegeli said. He also noted that airbags failed in 20 percent of accidents—of those failures, 60 percent was user error. The message? Check over your airbag and practice inflating it often, at least once a season.

2. We Need to Look Out for Each Other, Now More Than Ever

"We're really interconnected," said Trent Meisenheimer, a forecaster with the Utah Avalanche Center during his presentation titled "How Freedom of the Hills Has Become Anarchy in the Backcountry." "It's not just us out there. We've gotta realize that." Meisenheimer and his Utah Avalanche Center colleagues propose developing a social contract or backcountry skier responsibility code to promote inter-group safety off piste.

3. Avalanche Education in the U.S. is About to Change

"If you look at the avalanche education system across the United States, it's kind of all over the charts," said Dallas Glass, of the American Avalanche Association. "We actually need dedicated training for recreationists and dedicated training for professionals." That change is coming in winter 2016-17, with separate, dedicated avalanche-education tracks for professional and recreationist.

4. Uncertainty Matters More Than We Know

"When people have good information about uncertainty, they tend to distinguish more; they tend to discriminate better," said Susan Joslyn, a cognitive psychologist and Associate Professor at the University of Washington. Joslyn presented on how people understand uncertainty, stating that the best messaging suggests a most-likely outcome (i.e. what will likely occur) and offers advice and estimates of uncertainty (i.e. travel advice and how likely an outcome is to occur)—worthy notes when considering how avalanche forecasts are presented.

> Risk management in the mountains should be based on the rhythm of the mountains and the people that you're with.
> —Martin Volken

Martin Volken sets up his sliding scale of rating likelihood and consequences for the backcountry traveler.
Photo Rick Meade

5. Ask More Often: What if I'm Wrong?

Margaret Wheeler, the second woman in the U.S. to complete her IFMGA certification, also delved into uncertainty, discussing overconfidence and overexposure in the mountains. "Uncertainty is underrepresented in our decision-making process," Wheeler said, suggesting we should do more to quantify what we don't know before making a backcountry decision. "Ask: What is our list of uncertainties?" Wheeler said. "We have to match increased exposure with increased vigilance."

6. El Niño Isn't All Bad for the Pacific Northwest

With El Niño's track record of bringing warm winters to the Northwest, this year's predicted "Godzilla El Niño" might spell disaster. But it won't be all bad, says Washington State Climatologist Nick Bond. According to Bond, the so-called "Blob" that brought a near snowless season to Washington last winter has dissipated. For this winter, Bond says, "Our best estimate is that our snowpack will be 75 to 80 percent of normal."

Former Northwest Avalanche Center Director Mark Moore now gets to be part of the audience rather than one of the organizers of NSAW. *Photo Rick Meade*

7.Computers Can't Quite Predict Stability

"Essentially, all models are wrong, but some are useful." That's how Kyle Van Peursem, a graduate student at Montana State University's Snow and Avalanche Laboratory, started his presentation, quoting statistician George C.P. Box. Van Peursem is exploring how meteorology can apply to avalanche forecasting and whether or not weather forecasting can predict snow stability. "Numerical snowpack prediction systems probably won't be the main tool for avalanche forecasting and wouldn't replace manual observations," Van Peursem said, "at least not in our lifetime."

8. Assessing Hazard? Focus on Consequences and Likelihood

"The elements of consequence and likelihood are always linked in hazard evaluation," said Martin Volken, owner of Pro Guiding Service. Volken proposed a simple, numerical scale of quantifying a hazard's likelihood and consequence, adding the totals and determining whether or not that quantity falls beyond your level of acceptable risk. "Risk management in the mountains should be based on the rhythm of the mountains and the people that you're with," Volken said.

9. Continue Your Education

Avalanche education doesn't stop after taking an Avy 1 course, and NSAW was a refreshing reminder of the need to constantly brush up on skills and knowledge. Seeing the workshop's large and diverse audience was inspiring, and I'm excited to attend a regional snow and avalanche workshop again next fall.

Tyler Cohen is Editor in Chief of Backcountry Magazine and lives in northern Vermont with his two favorite ski partners, his wife, Rachel, and border collie, Niva.

Thanks to NWAC board member Rick Meade of Nikwax for the use of his photos.

THE 1ST ANNUAL WYSAW IN REVIEW

BY JAKE URBAN

On November 7th the Teton County Search and Rescue Foundation presented the first annual Wyoming Snow and Avalanche Workshop (WYSAW) in Jackson, WY. Over 300 delegates attended with over 20 industry vendors on hand for a mini trade show. The theme of this year's WYSAW was "A Conversation About Risk."

While this workshop was focused on professional development it was open to the general public as well. The unique mission was "for the professional community to engage the recreational community in the professional dialogue".

As this year's Master of Ceremonies, *The Avalanche Review* (*TAR*) Editor, Lynne Wolfe kept presenters on task. She provided informative and humorous introductions while prompting hard and difficult post presentation questions for contemplation by the audience and sometimes stumping the speakers as only Lynne can do.

Keynote speaker Grant Statham from Parks Canada kicked off the event. Grant engaged the audience for an hour with his presentation on the history of avalanche risk management in Canada. This compelling presentation focused on the backcountry practices before the legislation imposed after the January 2003 avalanche tragedy and how the backcountry culture in Canada changed because of it. Grant's 20 years of hindsight was a great reminder of the importance of changing our perceptions in order to improve our performance and outcomes.

Three sessions on risk management followed: A Practitioner's Approach to Risk, Institutional Risk Management, and finally Personal Responsibility Involving Risk Management.

Bob Comey initiated the Practitioner's Approach to Managing Risk and was followed by Kelly Elder and Bill Anderson. Bob's entertaining and informative approach brought new insight into traditional concepts during his presentation of the Unique Properties of Snow and Ice. The dead-pan delivery of Kelly Elder kept the fun factor and entertainment value high with his delivery of Snowpack Energy Balance in the Avalanche World. This first session was concluded by Bill Anderson's thoughtful, technically savvy yet easy to understand and applicable presentation on fracture mechanic and propagation named Fracture: Implications for the Modern Practitioner's Snow Pit.

Speaker's breakfast (fueled by coffee and donuts) before WYSAW: left to right: Drew Leemon, Jaime Musnicki, Kelly Elder, Alicia Peterson, Greg Epstein, Bill Anderson, Scott Guenther, Brint Markle, Grant Statham, Bob Comey, and Lynne Wolfe. *Photo Jake Urban*

Teton Gravity Research (TGR), Avanet and NOLS were represented during the session on Intuitional Risk Management. Film Producer Greg Epstein and Lead Guide Kent Scheler of TGR provided a behind-the-scenes look into the risk management process behind the making of some of the most popular ski films in the industry. Brint Markle of Avatech introduced their latest product Avanet. A trip planning and conditions reporting smart phone app. Finally, Drew Leemon , Director of Risk Management for NOLS provided insight into the rewards of risk and the culture of NOLS risk management.

The final session on personal responsibility began with a presentation by Dr. Alicia Peterson who took an in-depth look at the ICAR recommendations on Resuscitation of the Avalanche Victim. Additionally, Dr. Peterson made recommendations on the minimum medical training necessary for the backcountry traveler (professional and recreationist) that included Basic Life Support (BLS) training in airway management & CPR complimented by Wilderness First Responder level medical training. This addition from the medical community seemed far overdue and provided a unique outside perspective into necessary training for all levels of backcountry enthusiasts. See page 40 of this *TAR* for a deeper look at these protocols.

Scott Guenther of Grand Teton National Park then walked us through several winter incidents, fatalities, and rescues of the last few years, highlighting the Park's roles and responsibilities in each.

Drew Hardesty of the Utah Avalanche Center concluded the day's events by moderating a panel discussion that included individuals representing the following industry niches: avalanche survivor, professional rescuers, action sports film producer, ski athlete and avalanche forecaster. This session, while likely the most controversial, proved to be an excellent venue for difficult questions and answers that engaged many members of the audience and provided plenty of topics of conversation during the trade show that followed.

The evening was concluded with the roll out of Teton County Search and Rescue Foundation's new public safety campaign Backcountry Zero, a four-season community-based approach to limiting fatalities, injuries, and rescues in the Teton backcountry. The Backcountry Zero roll out concluded with the showing of Jimmy Chin's feature film Meru.

The 1st Annual WYSAW was extremely successful, well-attended and received great reviews. We hope to see you next year!

Jake Urban owns and operates Jackson Hole Outdoor Leadership Institute and is the Deputy Director and Training Advisor for Teton County Search and Rescue. When not teaching or training you can find him sliding on snow, rolling over or clinging to rocks in and around the mountains of Jackson Hole.

ESAW

BY JONATHAN S. SHEFFTZ

The fifth annual Eastern Snow & Avalanche Workshop (ESAW) was held on November 7, near the base of Mount Washington in New Hampshire's Presidential Range, and attracted a record of more than 225 attendees.

This year's ESAW was once again a collaborative effort. The organizing partners included the Snow Rangers of the USFS Mount Washington Avalanche Center, led by Chris Joosen, and the Mount Washington Volunteer Ski Patrol. ESAW also relied on a grant from our lead sponsor, the American Avalanche Association (AAA), which is led here by AAA Eastern Representative Chris Joosen and your faithful correspondent as AAA Member Representative. Additional support came from the American Alpine Club and our headline industry sponsor Outdoor Research. Registration fee proceeds (over and above hosting costs) benefited the White Mountain Avalanche Education Fund, which provides avalanche education to youth in the Northeast.

ESAW 2015 kicked off Friday evening with a social event hosted by the Friends of Mount Washington Avalanche Center and fueled by Smuttynose Brewery at the International Mountain Equipment shop and guide service. Avalanche presentations began on Saturday morning at the aptly named Grand Ballroom of the Mount Washington Hotel, famed site of the 1944 Bretton Woods Conference that established the post-WW2 international monetary order (including the International Monetary Fund and the World Bank).

Although your faithful correspondent's economics expertise pales in comparison to that of the 1944 conference's John Maynard Keynes et al., our ESAW speaker line-up this year measured up to the best of them. Read on for proof. (And no more economics references, promise!)

Chris Joosen introduced the first theme of Warming. Dr. Bruce Jamieson, retired professor from the Applied Snow and Avalanche Research program at the University of Calgary (along with far too many other positions and accomplishments to enumerate here), presented on "Warming of Dry Snow: Instability and Decision-Making." When Bruce offers training on this topic, the response is often, "come back in March," but this phenomenon can occur at any time of the season, even during otherwise wintry conditions. Assessing its potential is complicated by the lack of any direct numerical forecasts for solar radiation, as opposed to precipitation, temperature, and wind.

And if that was not sufficiently technical for us, the snow science level was ratcheted up by Dr. Sam Colbeck, who retired from the U.S. Army's Cold Region Research and Engineering Laboratory in Hanover, NH after three decades of groundbreaking research in snow crystal bonding and wet grain relationships. In his fourth year presenting at ESAW, Sam explained "the Physics of Warming." The scale of the talk varied from micrographic pictures of snow crystals to the varying effects of global climate change upon Greenland versus Antarctica.

The next theme was Communicating Avalanche Information. Don Sharaf, co-owner of the American Avalanche Institute and forecaster for Valdez Heli-Ski Guides, presented on "Communicating Avalanche Information Effectively within Operations." Along the way, he touched on the misconception of "too cold for avalanches," noting that a colleague once saw an avalanche at -48F.

We were then whisked away from Alaska to Europe by Dr. Rudi Mair, Director of the Lawinenwarnzentrale (Avalanche Crisis Center) for the Tyrol region of Austria, who spoke about "Avalanche Danger Patterns." The "clearly predicable course of events" for most avalanches was illustrated by many incidents that concluded with variations of, "he was found clearly dead." Though the his-and-hers paragliding avalanche incident was certainly an example of an atypical context!

From there we went up into the "Cloud" for "The Impact of Social Media on Decision-Making," presented by Jerry Isaak, Chair for the Department of Expeditionary Studies at Plattsburgh State University of New York. Although we can easily be dismissive of selfie-stick narcissism, social media is simply the modern technological expression of the ancient human impulse to tell stories. See *TAR* 32.2 for an article by Jerry on this topic.

Dr. Bruce Jamieson presented on "Warming of Dry Snow: Instability and Decision Making."
Photo David Lottman

After the lunch table, we were treated to a round table discussion on "Traveling into New Terrain: Responsibilities, Questions, Risk, and Making Good Decisions," moderated by Chris Joosen, with participants Bruce Jamieson, Don Sharaf, Rudi Mari, and Jerry Isaak. The most dramatic example was probably a trip Jerry has planned for this coming season with his university students to Kyrgyzstan!

We then retreated to nice, safe, bucolic Vermont, the neighboring Green Mountain State, which is perhaps not always so safe in all locations, as Neil Van Dyke, SAR Coordinator for the Vermont Department of Public Safety, reminded us with "Avalanche Terrain of Vermont." This is not merely a conceptual threat; a decade ago Neil led the response to an avalanche fatality in Vermont.

The final theme was Stability Analysis. Don Sharaf led off with the highly pertinent: "Easterners Heading West on a Backcountry Ski Vacation: A Stability and Decision Approach." Among a wealth of valuable advice, he reminded us to: "listen to the locals … but don't necessarily trust them." (So apologies in advance if any of us sound skeptical this coming season when soliciting beta from you!)

Then Bruce Jamieson presented his address, "Field Observations and Snowpack Tests: which is Best When?" Subsequently, Rudi Mair presented on "Avalanche Forecasting Operations."

We concluded with our annual expo, including displays from reps for the American Alpine Club, Backcountry Access, Black Diamond/Pieps, Catamount Trail Association, Dynafit/Pomoca, Friends of the Mount Washington Avalanche Center, Hagan, La Sportiva, Mammut/Barryvox, and Outdoor Research. We raffled off donations from these companies, as well as the American Avalanche Association, American Institute for Avalanche Research and Education, DPS Skis, Free Range Equipment, Mountain Hardwear, MSR, Ortovox, Sterling Rope, Toko, and Voile.

In a break from tradition, instead of subsisting for the rest of evening on scarfed-down free pretzels at the expo, we sat down for a formal dinner at the hotel. This was a memorial to Ronnie Berlack and Bryce Astle, U.S. Ski Team alpine racers who died in an avalanche ten months ago in Austria. Rudi Mair delivered the keynote address on "How do We Deal with Avalanches and Their Mortal Dangers when We Can't Understand the Risks in Their Whole Complexity?" Next, a U.S. Ski Team racer who was with Ronnie and Bryce at the avalanche incident addressed us via video. The night was capped off by a heartfelt address by U.S. Congresswoman Ann McLane Kuster and prepared remarks from U.S. Senator Jeanne Shaheen, read by Chuck Henderson, her Special Assistant for Projects and Policy.

By far the most moving moments were a tearful address from Bryce's mother that brought many of us to the same, and one line in particular from Ronnie's mother, which summed up everything we are all trying to achieve:

"We want to keep you from suffering our loss."

Jonathan Shefftz lives with his wife and mondopoint-size 18 daughter in Western Massachusetts, where he patrols at Northfield Mountain and Mount Greylock. He is an AIARE-qualified instructor, NSP avalanche instructor, and AAA governing board member. When he is not searching out elusive freshies in Southern New England or "coaching" his daughter's skiing (i.e., picking her up off the snow), he works as a financial economics consultant. He can be reached at JShefftz@post.harvard.edu.

MSU student doing beacon search on campus during MSU SAW.
Photo Sepp Jannotta

MSU SAW

BY JERRY JOHNSON

With a nod to the trend emphasizing the "human factor" and decision making while in potential avalanche terrain, Montana State University in Bozeman hosted the first ever MSU Snow and Avalanche Workshop in November. Bozeman may have been the last important ski destination in the country not to have a yearly SAW, and hopefully, we will now hold one a permanent basis. For this inaugural event, we preregistered almost 450 attendees, mostly MSU students, over half of whom self-identified as BC novices.

A SAW in a college town like Bozeman is necessarily different than other locations. Every year, over 3000 freshmen arrive with fly rods, skis, bikes, etc. MSU administrators make sure a good portion of them have seen the marketing claim that Bozeman is one of the "Top Ten Universities for Skiing & Snowboarding" in the country. Thus we can assume that there is a large number of novice, would-be BC skiers looking for the easily accessible sidecountry adjacent to the Bridger and Big Sky resorts, as well as the numerous mountains in the Bozeman region. It also means we have a steady supply of potential accident casualties near the bottom of the learning curve. In fact, only an hour or so after Gallatin Avalanche Center forecaster Eric Knoff ran through several cases of local avalanche accidents, the staff of the Center had to rush off to a skier accident in nearby Hyalite Canyon.

We were lucky to kick off our event with author David Page who had just recently completed the *Powder Magazine*/Black Diamond-sponsored Human Factor 2.0 web-based multimedia series. David has been thinking and writing about a wide range of risk and decision issues for the past year or so.

Doug Chabot always delivers with enthusiasm and a depth of experience that keeps a crowd of over 400 listening intently. He introduced a new theme for the Gallatin Center: "Know What's Under Your Feet." The emphasis is on digging, talking, and deciding. His take-home is fundamental: digging snowpits is important and increases our margin of safety. After a panel that included accident case studies, the MSU Tracks Project, and Bridger sidecountry, the large group divided. The regional professional community heard about the new AVPRO training curriculum from Jaime Musnicki, Executive Director of the American Avalanche Association.

At the same time and in the spirit of getting new backcountry skiers started on the right foot, we held an experimental "beacon fest." We showed a series of BCA beacon-oriented videos and set up a new BCA wireless beacon park outside. It looked pretty chaotic, but well over 100 people got some introduction and warm-up with a variety of transceiver brands.

Our medical speaker covered basic winter self-care and first aid. We wrapped up the afternoon with a panel of industry reps from Mammut, Avatech, and BCA answering questions about product design and avalanche education from Yellowstone Club pro-patroller Dave Zinn.

Our last speaker took us on a global tour from Greenland to the Southern Ocean, and to Antarctica by way of New Zealand and the U.S. The journey took place on skis and in kayaks, climbing ice and rock, and on foot across arctic deserts. In this talk, Graham Charles demonstrated his Kiwi wit and his vast expedition experience, as well as lessons learned from speaking to some of the top MBA programs in the country about risk and decision-making. He taught theory and practice to a crowd that maintained their enthusiasm to the end.

What really excited us about this SAW was the quality of questions that came from students just starting to learn their backcountry craft. This is what makes hosting the event at a university fun. I think that the secret to holding the attention of students who would rather be outside skiing is to tell an emergent story. Starting with a conversation about initial decisions in the backcountry, we were able to create a discussion that culminated in a larger analysis of risk in multiple settings.

We are very lucky to have a strong support infrastructure behind us. The friends and staff of the Gallatin National Forest Avalanche Center were central to our success, as was the Outdoor Program at Montana State University. Through the use of our public facilities we were able to keep costs low and admission free to everyone this year. Thank you to everyone who participated. Video footage of the event can be found at http://www.montana.edu/snowscience/tracks.html?origin=snowscience ▲

PRO / REC SPLIT: RECREATIONAL GUIDELINES UPDATE

INTERVIEW OF KIRK BACHMAN BY SEAN ZIMMERMAN-WALL

We are in the midst of a great sea change in avalanche education, and it is time to start preparing for the myriad challenges that lie ahead. As mentioned in Volume 34.1 of *The Avalanche Review*, the American Avalanche Association is forging ahead with the Pro/Rec Project in an effort to develop improved guidelines that will help providers better serve the specific needs of each user group. Through continued collaboration and information exchange by various entities in the industry, the original proposal is moving forward into a full-scale plan. Kirk Bachman of the AAA Education Committee, who initially served as the project manager, is now serving as the Pro/Rec Project Advisor and is focusing more on the recreational side of the equation. His foresight in laying a solid foundation enables the AAA to continue defining the roles of those involved with the behind-the-scenes work associated with the Project. It is now a matter of putting the pieces that have been so meticulously crafted into place to make the whole clock tick. To reach that end, Bachman is striving to bring increased awareness of the direct actions that will need to take place in order to ensure a smooth roll out for the 2016/2017 season. The following interview will help paint the picture of what is transpiring and add context to the Project as it pertains to the recreational stream and its nuances.

> A key part of developing improvements for future formal training programs is to link to the success of programs currently doing a great job with messaging.

How has the Project metamorphosed over time and how have those involved helped you stay on task and meet stated objectives?

Through surveys and outreach, the formation of working groups and meetings, as well as input and feedback through AAA pro membership, these processes have provided ongoing direction and served to refine goals. Broad avalanche community support has provided a variety of engagement and valuable communication useful to the various working groups for development of the Pro side and the Rec side of the Project.

On the Recreation side, having the AAA's Education Committee solicit feedback from a wide spectrum of those who provide education programs to the public has been critical to updating and making improvements for all types of winter recreationists: backcountry skiers and riders, both motorized and non-motorized.

Many existing entities have launched very successful avalanche education programs through public outreach via regional Avalanche Forecast Centers. A key part of developing improvements for future formal training programs is to link to the success of programs currently doing a great job with messaging such as "The Avalanche Project" and "Know Before You Go". These programs are natural partners in providing a link to additional recreational avalanche training and their place in the community is invaluable for getting the word out.

Entities providing feedback for the REC Guidelines are American Institute for Avalanche Research and Education, National Avalanche School, American Avalanche Institute, Gallatin National Forest Avalanche Center, Colorado Avalanche Information Center, Utah Avalanche Center, Sawtooth NF Avalanche Center, National Ski Patrol, Alaska Avalanche School, Silverton Avalanche School, Lake Tahoe Community College, American Alpine Institute, Sawtooth Mountain Guides, University of Alaska, plus numerous AAA pro members.

What are the latest initiatives taken by the AAA Education Committee to peer review the goals of the project and ensure its efficacy?

By design, the AAA's Education Committee has a good representation of avalanche education providers who specialize in recreational avalanche education. This group has a focused and positive view on the improvements being made for the Recreational Avalanche Education Stream. A collection of representatives for education entities in the US has reviewed and agreed to details for a progressive and relevant set of guidelines for new courses. The AAA Education Committee feels that next steps are to get these updates for courses out to avalanche educators and the public. By doing so, the recreation world is more aware of what has changed and the increased opportunities for training.

Can you elaborate on the rationale for each new course for the Recreational Stream and discuss how they were devised?

In reviewing the previous Guidelines, which were last visited in 2007, we asked ourselves what had changed or needed improvement. Over the last 10-year period there has been a surge in popularity for heading into the winter on skis, snowboards, and sleds. New courses needed to provide practical and useful topics and practice skills that will better serve all recreationists. With our new approach in creating separate training, this provides the opportunity for more relevant course content and learning outcomes which are better suited to what recreationists need and will focus on during a course-- making good decisions when recreating in avalanche terrain and doing a better job of managing risks specific to each user group.

Avalanche Rescue is a stand-alone course for all recreationists. It has no pre-requisites because it is a course everyone should take regardless of mode of travel. This is a re-design of the shorter Companion Rescue course, which is used as a shorter field activity or module of a Level 1. As an 8-hour course, Avalanche Rescue provides more time for practicing all the elements of rescue: beacon use and search strategies, probing and shoveling techniques. The goal is to have students practice a number of scenarios to organize and respond to an incident in their own group or a nearby backcountry group. Using a checklist to organize and manage the complexity of a rescue response is emphasized. The student also is introduced to the need to address the medical side of evacuation of the victim and reaching out for outside help. As a more robust treatment of avalanche rescue skills, it will serve as a pre-requisite for the Level 2 and for entering the Pro side of the education stream.

Level 1 Avalanche Training addresses learning outcomes and practical skills all recreationists should utilize and apply when recreating. While the student is exposed to background as to why and where avalanches occur along with the necessary conditions, more emphasis is being placed on understanding the importance of gathering information and developing a plan with your backcountry partners prior to heading out for the day in the field.

In the last ten years, web-based information has vastly expanded and is widely available. In particular, the information available by regularly visiting regional avalanche bulletins and forecasts is the single best tool all recreationists can use in order to have your information up to speed. For this reason understanding and using an avalanche bulletin is front and center as a learning outcome on a L1 course. Linked to this is taking the time to preview it with your group in order to understand the avalanche problems in your area and where in the terrain you are likely to find them. This requires that your group discuss these moving parts daily prior to selecting terrain. If there are questions about the snowpack where your group wants to go you have a better idea of why you would dig a pit to answer a question, or find the problems discussed in the bulletin and with your group. Head out the door with questions and have a more focused approach to your daily observations.

The Level 1 is a course aimed at developing knowledge and practices that will make graduates a reliable member of a backcountry trip.

The Level 2 Avalanche Training is a step up from a Level 1 but builds on many of the skills introduced on the fundamental course. Folks who have experience in the backcountry will find this new course really relevant to gain training in leading a group and addressing decisions on selecting and managing your group in avalanche prone terrain. The guidelines also emphasize the methods to select terrain without the benefit of having an avalanche bulletin.

Without the benefit of a bulletin, the Level 2 participant needs to develop a better understanding of avalanche problems and related terrain characteristics, and identify what information is needed from the field. A toolbox of observation skills and appropriate snowpack tests to align with the current avalanche problem provide the content for a Level 2. These students will gain a better understanding of tracking layers in the seasonal snowpack at the slope and peak scale and then linking avalanche problems to layering in the snowpack.

The practice of pre-field trip planning and utilizing observations from the group and other nearby resources allow Level 2 students to understand, communicate, and mange risks as a solution to addressing human factors. This course integrates the elements into a 'systematic method' for identifying and selecting terrain by providing leadership in this process of recognizing and anticipating the avalanche problem, and gathering information to be shared with your trip partners. Prior to heading into the field, the participant identifies gaps in information as well as uncertainties that help to direct critical observations for the day. Developing options for more conservative choices in terrain selection are part of the day's plan. Once in the field, practice of managing your group by implementing the daily trip plan and through ongoing communication and applied decision-making form the framework for this course.

What should students entering the Recreation Stream expect when they take their first course?

In this era of Social media, the working group members via the AAA Education Committee want to link formal education content with some of the strong messaging coming from popular avalanche awareness campaigns such as "The Avalanche Project" and " Know Before You Go." These programs have laid out a resonating message to a broad audience : Get the Gear, Get the Training, Get the Forecast, Get the Picture, Get out of Harm's Way.

In effect this is a catchy way to hammer the importance of checklist use, educating yourself and practicing avy and rescue skills, use avy bulletins, plan and prepare to travel in avalanche terrain by staying out of dangerous situations and conditions.

The Level 1 Avalanche Training is a formal 3-day training exposing the student to related knowledge, concepts, and practical skills in order to join and be a contributing member of a backcountry trip in and around avalanche terrain.

What key components do current course providers need to understand about the changes in the course structure?

At this juncture, course providers must be engaged to make adjustments to what is being emphasized on their courses. As far as the Level 1 Avalanche Training, students still need a background on fundamentals which are based in science relating to terrain, snow, and weather. It is critical that students learn how to understand and follow avalanche bulletins in their area and plan and prepare with their recreation partners prior to heading into avalanche terrain. For course providers this means designing the courses so more emphasis is placed on gathering current info on conditions and avalanches in the area, AND to provide opportunities to plan and prepare with your trip partners each day. At this stage, Level 1 students really aren't equipped enough to be 'on point' when making stability evaluations. It is better to gain some experience by making key observations-- looking around and verifying conditions and problems that were stated in the avalanche bulletin. Finding good backcountry partners who utilize good practices should also be a key post-course message. Level 1 students need to gain experience and learn to apply good practices.

With the redesign of the Level 2 Avalanche Training, the student is better prepared to combine time and experience in the field with good partners in order to delve deeper into the processes of making stability evaluations. If students don't have the benefit of an avalanche bulletin, there is a method to use to gather information using resources at hand, and making more conservative terrain choices until the avalanche hazard and the avalanche problems are better understood. Again for the course provider, there needs to be an emphasis on practicing teamwork, planning, making observations, and using appropriate tests for the current conditions. Opening and closing terrain based on conditions and 'Gaps in Knowledge' or due to the avalanche hazard or nature of avalanche problem should also be an applied facet of a Level 2 Course.

Are there suggestions for current providers to review their curriculum and set themselves up for success as the Project moves forward?

If as a Course Provider, you are not part of a larger organization which provides curriculum updates for you, then I would recommend that you closely study the new guidelines and critically review what changes need to be made with your course emphasis. Start by addressing the 'New Learning Outcomes' and then focus down on the new curriculum content. Compare and contrast what your past program has emphasized and determine to what extent a new direction and focus in needed.

Does the AAA have a defined process for becoming a listed course provider, and what value does that have in the long run?

The AAA has had a formal program for Avalanche Course Provider Listing at the website Avalanche.org since 2010. Engaging and participating in this program has many benefits for all course providers. For starters, as a portal, Avalanche.org is a great place to see who teaches avalanche education in the US state by state. In making an application to participate in this listing program, the course provider links their education program with professional membership in the American Avalanche Association. The application process is relatively straightforward and provides a method to confirm that your program is in-line with the fundamental standards for being a course provider who teaches courses that are consistent with the AAA Guidelines for Avalanche Education in the US.

This process is detailed at www.americanavalancheassociation.org/course-providers.

Bachman's responses illustrate just how critical a change this is for providers of avalanche education and should help to alleviate some of the cloudiness surrounding the recreation side of the Project. The AAA Education Committee is very interested in making sure providers feel they have the tools necessary to carry out a smooth implementation of the updated guidelines, and will continue to engage the AAA membership in the process.

At the publication of this article, the conclusion of the Project revolves primarily around hammering out the intricacies on the professional training side. There is still work to be done regarding the vetting of instructors to teach these pro courses and ongoing collaboration with various industry segments remains paramount to a timely roll out. Oversight by the AAA of these pro courses is also a big part of ensuring that the benefactors in the industry (ski areas, guide outfits, forecast centers, etc) are able to understand the level of training their employees receive. Making a strong connection between the two streams and giving the next generation of snow professionals a solid foundation is also a top priority. Stressing the importance of mentorship and time in the field is pivotal in fostering the development of competent and confident professionals that will continue to add to the robust community that the AAA has worked to establish.

Stay tuned to *The Avalanche Review* and americanavalancheassociation.org for more updates and info. ▲

CORE CURRICULUM

LEVEL 1 AVALANCHE TRAINING: For Current and Aspiring Backcountry Travelers

PRE-COURSE

- Consider pre-course materials and study for student
- Avalanche Basics & Characteristics
- Avalanche types; Unstable snowpack conditions
- Size classification of avalanches, Incident statistics
- Terms common to: avalanches, terrain & snow
- Avalanche motion: glide, turbulence, speed- dry vs. wet
- Identify Avalanche Problems (conditions, formation, characteristics)

TERRAIN

- Critical slope angles. Terrain features, shape, size
- Role of slope aspect and elevation to sun and wind
- Identify avalanche start zones, tracks, and runouts
- Critical terrain: traps, convexities, triggering.

SNOWPACK AND WEATHER

- Mountain snowpack development: storms, intervals. Weather events leading to formation of strong and weak layers. Basic snowpack development/change.
- Snow Climates; by region and within range-mountain location

INFORMATION GATHERING

- Access and understand information from the Avalanche Advisory. North American Avalanche Danger Scale
- Use of terrain/danger rose

PLANNING, COMMUNICATION & DECISION-MAKING

- Terrain, Snowpack, Weather discussion for trip planning
- Use information to plan & prepare for field. Use of Maps/technology
- Human Factors, Managing Risk
- Use of decision tools, check lists, contingencies, emergency plans
- Communication
- Application of Plan to Field. Tour group decision making prior to travel; safe travel for conditions. Relevant observations & objectives.
- End of day review. Observations and reflections with group.

MAKING RELEVANT OBSERVATIONS

- Field observations: Critical Red Flag Obs.; Recognizing & prioritizing
- Pairing appropriate observations with current avalanche problems and conditions
- Use of avalanche & snow pit tools: inclinometer, compass, probe, saw, shovel, and thermometer
- Snowpack tests: snow pits: ID layers (hand hardness), basic grain types (strong & weak layers). Verifying the Avalanche Problem.
- Informal snowpack tests while traveling

TERRAIN AND TRAVEL

- Trailhead Check (beacons/equipment)
- Observant Travel/ snow, weather, terrain
- Route selection. Managing group in terrain: travel protocols & group communication.
- Terrain identification. Recognize slope scale features. ID Avalanche terrain. Safe terrain choices.

BASIC AVALANCHE COMPANION RESCUE

- Beacon use, probing, shoveling
- Simple one and two person burial techniques
- Incident Response-Leadership, safety, checklists. Developing a plan based upon terrain, avalanche size, and resources.
- Response as an avalanche victim; as a rescuer
- Special Problems/ Common mistakes
- Role of first aid and emergency response in real avalanche rescues

CONTENT FOR THE THREE RECREATIONAL CLASSES

AVALANCHE RESCUE: For Winter Recreationists That Travel In Backcountry Settings

AVALANCHE RESCUE PRINCIPLES:

- Survival rates and times
- Victim demographics and statistics
- Review of avalanche avoidance
- Escape and survival techniques if caught in an avalanche
  Rescuer safety/ Response
- Recent developments & research

AVALANCHE GEAR & TECHNIQUE:

- Digital Beacon –multi antennae 457 kHz Standard (modern technology)
- Probing & Shoveling Technique
- Additional optional safety gear/ Response
- Airbags, Avalungs
- Helmets
- Recco
- Rescue Dogs/ Dog Handlers
- Organized Probe Lines

COMPANION RESCUE PROCESS:

- Scene Safety and Size-up
- Communication, organization & leadership
- Last Seen Area (Number of Victims)
- Activating EMS
- Search Techniques (spot, Rapid Response)
- Transceiver Search- signal, coarse, fine
- Pinpointing technique - probe
- Non-Transceiver Search
- Probing Shoveling practice/techniques
- Trouble shooting common problems
- Group Management
- Deep Burials
- Multiple close proximity burials
- Communications
- Scene Size-up / Reporting

AVALANCHE VICTIM BASIC PATIENT CARE:

- Briefly describe and anticipate common medical and trauma problems. To include Resuscitation, Hypothermia and Trauma Management

RECOGNIZING NEEDS AND IDENTIFYING ADDITIONAL RESOURCES:

- Medical, Backcountry Transport
- Introduction to ICS & EMS resources
- Basic Helicopter operations: LZ, basic hand signals

LEVEL 2 AVALANCHE TRAINING: For Advancing Winter Backcountry Travelers With Prior Avalanche Training And Experience

PRE-COURSE

- Review Avalanche Fundamentals
- Consider additional, targeted pre-course material for students to facilitate foundational topics

CONCEPTS IN AVALANCHE HAZARD

- Identify/review Avalanche Problems (conditions, formation, characteristics)
- Avalanche Character + Location(s) and distribution of the Avalanche Problems, sensitivity to triggering
- Integrate likelihood, exposure, consequence, and trend concepts

UNDERSTANDING AVALANCHE RELEASE

- Understanding avalanche release – initiation, fracture, propagation
- Snowpack characteristics, and Triggering

SNOWPACK & WEATHER

- Relate seasonal snowpack layering to weather events/history
- Storms (layers) and non-storm intervals (surfaces, weak layer formation), leading
- Avalanche events -linking snowpack structure to Avalanche Problems
- Layer formation processes- fragments, rounds, facets, surface conditions
- Influences of wind, temperature, snowpack depth on layer formation
- Relevance of settlement, creep, and glide; links to snowpack stability

TERRAIN

- Scale of terrain- region, range, basin, slope, features avalanche paths and specific terrain features
- Link terrain aspect and elevation to avalanche problems & character
- Identify snow cover over terrain. Snow cover distribution weak/ shallow; strong/deep. Track Stability & snow quality.
- Use of terrain rose to illustrate and track Avalanche Character, and safe terrain with snow quality
- Estimate avalanche size(s) given terrain scale and avalanche character

APPLIED INFORMATION GATHERING & PLANNING

- Review a current avalanche advisory for reference when available
- In lieu of (or in addition to) public avalanche forecast, identify local and internet resources for snow, weather, and avalanche information
- Utilize Field Book- for documenting critical Information
- Relate weather station data to snowpack history and current snowpack observed
- Identify key information and questions to consider in estimating avalanche hazard and problems
- Incorporate recent observations and reports to assess present conditions
- Identify and manage areas of uncertainty with targeted observations and appropriate terrain selection and boundaries
- Review and practice basic trip planning outline presented in Avalanche Fundamentals (i.e. group objectives, leadership, decision points, contingencies, and emergency plans)
- Use maps and map technology to identify simple, challenging, and complex terrain in local area. Anticipate terrain challenges given Avalanche Character.
- Plan route, objectives, and terrain options for current snowpack and weather conditions
- Consider communication and emergency response options for day and multi-day or remote trips

COMMUNICATION, TEAMWORK & DECISION-MAKING

- Human factors revisited, identify influences of individual and group factors
- Communicate to identify objectives/goals (ensure full group buy-in), establish teamwork/roles, and manage group
- Consider and communicate about group goals, abilities, motivations, and limitations throughout the day; impacts of these factors on route and terrain selection
- Identify conditions in the field that may challenge communication and decisions
- Designate and follow through with group check-ins, decision points, and time frame for day

FIELD OBSERVATIONS & SNOWPACK EVALUATION

- Target observations & snowpack tests to fill knowledge gaps and address current/suspected Avalanche Character
- Identify and prioritize critical "red flag" observations of terrain, snowpack, and weather
- Pertinent weather observations and trends: sky-cover, wind, temperature, solar radiation, precipitation
- Additional snowpack observations: snow surface mapping, snowpack depth/distribution, settlement, note daily changes, link key weather and affect on snowpack
- Recording observations- Key concepts: Weather & snowpack obs. Drafting snow profiles
- Make observations and informal tests while moving through terrain
- Dig snow pits in relevant (aspect, elevation, Avalanche Problem), responsible locations
- Importance of craftsmanship and consistency for standardized observations
- Snow pit practices:
  – Identify layers
  – Perform snowpack tests appropriate to conditions
  – Note shear quality and/or fracture character
- Interpretation of pit results and integration with other snowpack observations
- Limitation of snow pits and value of multiple tests/locations to recognize patterns

TRAVEL

- Recognize gaps in knowledge prior to field travel and prioritize observations needed
- Trailhead Check: teamwork & communication, beacons & safety equipment
- Implement plan to field: route and trail; identify and use safer route alternatives when faced with changing or unanticipated conditions
- Practice group travel protocols appropriate to terrain (spacing, one at a time, safe zones)
- Group management techniques for safe and efficient uphill and downhill movement

End of day review:

- Observations of snowpack and instabilities, weather, terrain. Group teamwork, managing risk through the day
- Review close calls/mistakes, decisions
- Reflections, learning

Persistent weak layers: surface hoar that plagued the snowpack that year.
Photo Doug Braumberger

CHERRY BOWL AVALANCHE

BY DOUG BRAUMBERGER

INTERVIEW CONDUCTED ON DECEMBER 15, 2015 WITH JUPITER MACDONALD ON CHERRY BOWL AVALANCHE MARCH 17, 2013.

On March 17, 2013 two experienced groups of backcountry travelers ventured out in backcountry adjacent to Shames Mountain Ski Area. The first group, visitors from Whitehorse Yukon, and the second group, locals from the nearby town of Terrace BC, were traveling along the Zymacord ridgeline which allows access to several areas/bowls to ski. The avalanche danger had been fluctuating between Moderate to Considerable at treeline and alpine areas due to a deep persistent layer and surface hoar layers throughout the snowpack. The following interview is an account of that day.

Was the group or members of the group touring the day before? If so what observations or snowpack synopsis influenced the group's decision to select the route for Sunday?

I wasn't able to get out on Saturday but Brad and Matt were out touring in the area. In fact we met later that evening at a potluck dinner and discussed the current conditions and the persistent weak layers in the snowpack. The plan was to do more exploring to get a better idea on how the snowpack was behaving. On Sunday we met at Shames and decided to do a tour along the Zymacord Ridge with no specific destination in mind. The thought was to allow the conditions dictate possible ski options while traveling safely along the ridge line. After leaving the resort we skinned up to the top of an area called the Dome then skied down to a col that separated the Dome from the ridgeline. While we were skiing down the Dome we observed the Whitehorse group skinning out of the col area heading to the ridgeline.

What did the group observe while touring? Was the group making any observations of the snowpack as you were traveling?

Since the avalanche danger for the day was Considerable we decided to dig a hasty pit as we traveled. In our pit we observed buried near-surface facets, which yielded various test results so we made some mental notes on their location in the snowpack and aspects. We also noticed some recent avalanche activity between Geronimo and the Hourglass.

So you're traveling along the ridge heading towards Cherry Bowl and then?

Well as we continued along the ridgeline we approached two high points and noticed a hasty pit and ski cut at the top of G-spot *(2 on photo at right)*. We also noticed sets of tracks heading down into the bowl and concluded that the other group had skied down that line. We continued along the ridge to a low point *(3)* and began heading up on the uptrack. The ridge is wide along here more like a small knoll, about 100-150 feet wide. It was on the up track that we felt the "whumph" of the snowpack collapsing, that's when the person setting the up track noticed the avalanche across the bowl area *(3-6)*. As we approached the edge of the ridge to see the extent of the avalanche we watched the powder cloud explode across and up the other side of the valley. At that point we realized that the group from Whitehorse was down there and consumed by the avalanche.

How did you react when you realized that there were people down in the bowl and more than likely involved in the avalanche? What was the plan?

After a quick discussion and assessment on the situation and travel path, we stripped off our skins and began skiing down on the bed surface to a safe point along a ridge and then continued skiing down to the head of the deposition zone. That's when we encountered the one individual from the group not buried by the avalanche.

What was the individual's condition?

He was in a state of shock, wandering around the site with his beacon on search shouting "they're right here". Unfortunately he was reading our beacons and didn't understand that, given the situation. Also all his gear was gone since they were transitioning from skiing to skinning; he had nothing since it was buried in the debris pile.

How did he avoid the avalanche and where was he?

He saw the avalanche coming down on the group and was able to make it to a small stand of trees and grab hold of one of them. The amazing thing is afterwards when we looked closer at where he was during the avalanche we noticed that everything around him was impacted except for a teardrop-shaped area around the tree he was holding on to. The only conclusion we could come up with was that the avalanche had rolled up, over, and around him.

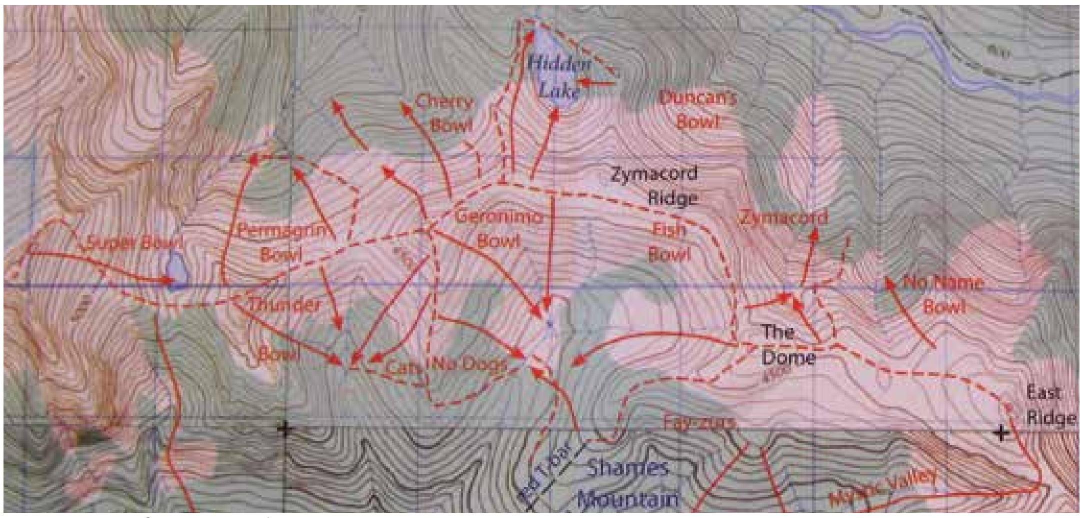
Your group is on the scene, made contact with the only individual not buried, then what happened?

It was at this time that Matt and Brad activated both their SPOT units; we turned our beacons on search and began working a grid pattern across the deposition field, looking for any visual clues that might assist in our search. Matt quickly picked up a signal, pinpointed it, probed and had a strike. Matt and Mikael then began digging the first victim out while I continued the grid search. I marked the first burial and continued searching down slope. I quickly picked up another signal and pinpointed it 1.9 meters down. I realized that it was a deep burial and decided to move to my third signal which was close by. I flagged that point, yelled my findings to the others, marked it. Brad arrived and started probing, had a strike and began digging. I picked up the third signal, pinpointed at 1.9 meters, marked it, started probing, had a strike and then started digging. In the meantime Matt finished digging out the first victim, cleared her airway. She then started breathing on her own and regained consciousness. Once she was completely extracted Matt helped dig out the other two victims. All of the victims had airways obstructed with snow, were hypoxic and hypothermic. But once the airways were cleared they began breathing on their own and they regained consciousness.

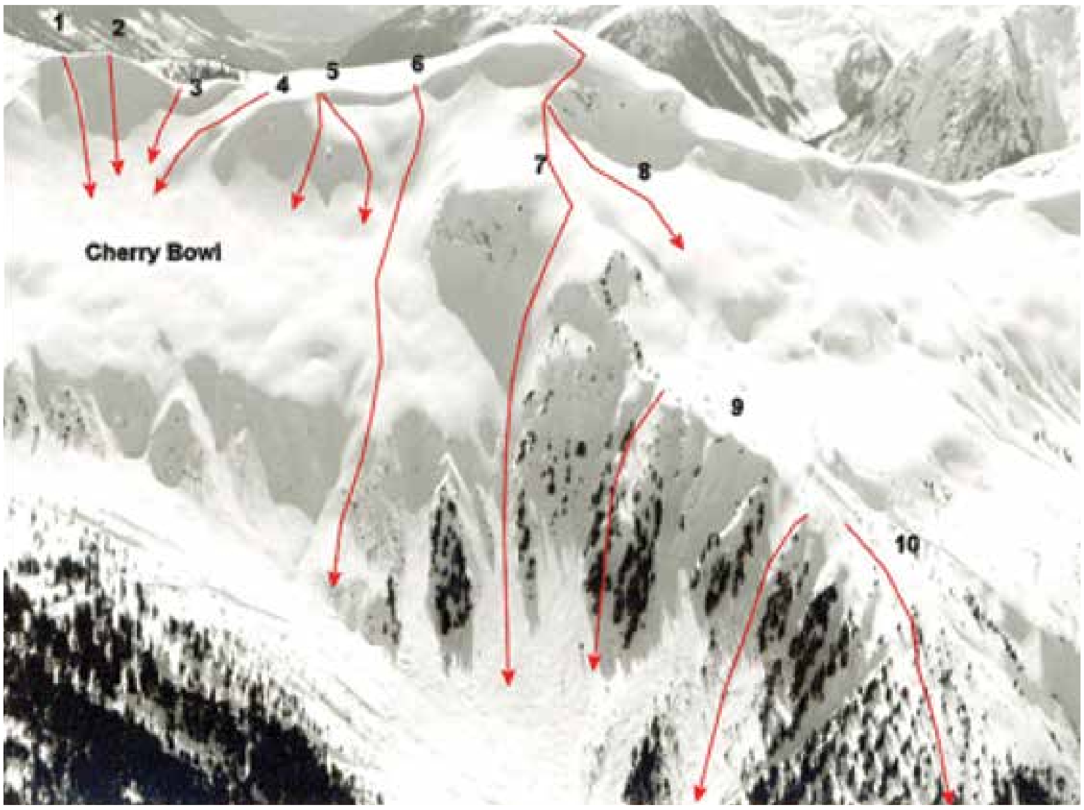
Were any of the victims seriously injured?

The third victim complained of back pain once he regained consciousness. I conducted a c-spine assessment and he had no signs of spinal abnormalities so we extracted him from the burial site. Shortly after that he began walking around and the pain decreased in his back. Aside from shock and mild hypothermia no one else had any injuries. Given the size and magnitude of the avalanche it's amazing no one was seriously or fatally injured.

At this point you have all the victims extracted, assessed for injuries and you're sizing up the scene. What's the group's next move?



Map courtesy of Doug Braumberger



Just west of Hidden Lake sits Cherry Bowl, and a full day tour. As well as some colourful route names, this bowl offers a mindblowing variety of skiable terrain. 1. G-spot right, 2. G-spot, 4. Down-the-uproute, 6. First Tracks, 9. Cherry Trees, 10. The Orchard. *Photo Rod Gee*

After we triage and addressed any first aid concerns we assessed the area and determined our current location was a terrain trap with multiple overhead hazards. We did notice an area of old growth trees about 300 feet upslope and decided that was a good safe zone. So we collected the group and relocated to that area. We then built a fire for warmth and wrapped the survivors in our extra clothes and space blankets. It was late afternoon and we were unsure if the SPOT signals had been received by anyone, so we developed an evacuation plan and prepared to spend the night out. Brad and Matt were the two fastest skiers so they left what gear they didn't need and any extra food or water with us and started back over the ridge to Shames for additional help. Mikael and I would stay back and keep the fire burning and monitor the survivors. Twenty to thirty minutes after Brad and Matt departed we heard a Northern Escapes heli-skiing helicopter fly over; it made visual contact with us then flew away. They returned after dropping off their guests at Shames, landed briefly onsite, deploying additional help before departing to survey the area for a safer landing zone. Brad and Matt skied back to rejoin the group. Once the landing zone was secured the helicopter returned and we loaded Brad, Matt, and the survivors into the helicopter and departed to Shames. Mikael and I remained and flew out later with the extra gear left by Brad and Matt.

What were the lessons learned from this experience that you can share with others?

Communication, training and trusting your partners.

Communication within the group was probably the key to managing the scene. Everyone knew exactly what the other guy was doing because we were constantly communicating. It allowed us to effectively and efficiently manage the situation including the challenges presented by the one unburied survivor.

Everyone had some type of training for this situation. Brad, Matt and Mikael had attended the Companion Rescue course at Shames several weeks before the incident. The course was an exact replicate of this situation with multiple burials, a shocky survivor, and chaotic scene. The course was an excellent training opportunity that allows everyone to discover their strengths and weaknesses and then work on them in a controlled environment.

And trusting your partner's decisions. No one at any time questioned the decision made by another person during this incident. That goes back to spending time out there skiing together and building a trust in that individual or individuals. ▲

MY CONNECTION WITH CHERRY BOWL

BY DOUG BRAUMBERGER

Jupiter, Brad, Matt and Mikael chose to share their story with me because there are strong messages from the event and its aftermath. Lessons I took from this event and from interviewing Jupiter inspired me to share their story with others.

This project started out as "Hey Lynne did you see the *Backcountry Magazine* article on the Cherry Bowl Avalanche?" From there it morphed into conducting an interview with one of the rescuers who happened to be a friend. We thought it might be interesting to get a more personal story from the rescuer's perspective since they have something very important to contribute to our community. In fact, all the rescuers involved in the Cherry Bowl incident are friends that I met while working on a project in Terrace, British Columbia.

Two weeks before the Cherry Bowl incident and under ideal conditions, Dave, Bryan and I toured that area and skied that line……it was amazing.

I also participated in the Companion Rescue course about one month before the incident. Local ski guide Hatha Callis took the time to organize and teach the course, which I feel contributed to the positive outcome for that day.

Terrace is a small town in northwest British Columbia that prides itself on being self-reliant and taking care of the beautiful mountains and rivers that surround the community. The backcountry ski community is a very close-knit group of individuals who spend as much time together off the snow as on. Potluck dinners are not uncommon weekend social events after a long day skiing out of bounds or at the local ski hill, Shames Mountain Ski Area.

LOCAL'S PERSPECTIVE ON THE CHERRY BOWL ACCIDENT

BY ROD GEE

The local backcountry community has a very active private Facebook page, so I posed the question there of whether, and how, the Cherry Bowl incident had changed perception of risk in winter backcountry recreational activities, approaches to managing accepted risk, trip planning processes, skills development, etc. I was particularly interested in people's route selection process where/when persistent weak layers are present. A PWL was a key part of the Cherry Bowl story, and PWLs are relatively unique in the classically Coastal snowpack found at Shames, though more frequently showing up than in the past.

Four themes in the replies stood out. One was the commitment to ongoing training. Rescue was the obvious topic, but formal and informal ongoing development of route selection and snow stability assessment were mentioned as well. This was an interesting high priority because, generally speaking, the local backcountry ski/board community already possesses an above-average skill set.

The second theme was the acceptance of carrying electronic devices for their effectiveness in bringing in outside assistance to supplement first party rescuer's skills and equipment. Note there is no cell service in the area around Shames.

The third theme was the value of freely sharing field observations of recreationists and professionals. Local backcountry society's, and other backcountry-related, Facebook pages, and Avalanche Canada's public avalanche bulletins and Mountain Information Network are all well used locally.

The final theme seemed to be a sort of background to the first three themes. The incident drove reality home that, though there had been few burials and no fatalities prior to this, the potential of the Cherry Bowl incident, combined with other factors, seems to have resulted in a more intense focus on risk tolerance and acceptance. The places being skied haven't changed but the go/no go decision making process is taken more seriously. And if anyone's "off the scale", there's little hesitation to open up dialogue about it. The community cares about each member, and nobody wants to see anyone getting themselves into any "tight spots."

Rod Gee is Principal and Senior Avalanche Specialist of Northwest Avalanche Solutions Ltd., based in Terrace, B.C. He is a Professional Member of the Canadian and American Avalanche Associations, past CAA Director at Large, and is the "lone Canadian" participant/observer of the Avalanche Artillery Users of North America Committee. Rod has spent "many" days in the Shames backcountry since the ski area's lifts started turning in 1990.

Zymacord Ridge with Cherry Bowl on the right. *Photo Doug Braumberger*

THE CHERRY BOWL STORY AT AVALANCHE CANADA

BY MARY CLAYTON, COMMUNICATIONS DIRECTOR, AVALANCHE CANADA

Story-telling is one of our oldest and most effective forms of communication. Humans are hard-wired to respond to stories; they help us make sense of the world and our place in it. When we at Avalanche Canada heard the story of an amazing avalanche rescue—a story that defies all odds—we knew we had to tell it to a wider audience.

This rescue took place in the backcountry near Terrace, BC. Cherry Bowl is a spectacular feature, about an hour's skinning from the Shames Mt ski resort. On a sunny day in March, 2013, two groups of four skiers headed in the direction of Cherry Bowl. One group, visitors from Whitehorse, were intent on hitting this choice line. The other group, locals from Terrace and a bit more wary of the conditions that day, were out for a ridge walk.

The Whitehorse group had some great turns but while they were in transition at the bottom of the bowl, they were hit by a size 3.5. One of them miraculously managed to stay on the surface but the other three were buried, all at least 1.5 m deep. The Terrace group, still high on the ridge, saw the slide and immediately went into action, performing an incredible rescue that saved three lives.

What really makes this story special is the fact that the Terrace group had very recently taken a companion rescue skills course. All avid backcountry skiers, they had taken it upon themselves to hone their skills for the season. Who could have known what a difference that training would make?

When our forecasters first heard about this accident, they immediately recognized its incredible potential as a learning tool. We were all still buzzing about *Snow Fall*, the Pulitzer-prize winning online feature published by *The New York Times* in late 2012 that tells the story of a fatal avalanche accident near Tunnel Mtn, Washington. *Snow Fall* is definitely an inspiration for digital storytelling and if you haven't seen it yet, do yourself a favor and take the time.

We wanted to do something similar—create an interactive site that allows the user to experience and explore different aspects of the story. We began by connecting with a US production team, Tinhouse Creative. They were in Terrace in early 2014 and taped amazing interviews with every person involved in the accident. We contracted them to produce a short, 8-minute video that we could use to raise money for this project.

Over the winter of 2014-15 we used this video to drum up support for the project and thanks to a number of sponsors, by the spring of 2015 we were in business. Work began over the summer to develop the site and as this issue of *The Avalanche Journal* goes to press, we are in the final stages of coding.

We are all very excited to get this project and we're counting the days to get it finished. There will be an announcement when the site goes live so watch for that soon. ▲

Thanks to these sponsors, we are able to bring this project to life.
MEC, Arc'teryx, Northern Escape Heli-Skiing, Northwest Avalanche Solutions Ltd., Golder Associates, Trans Canada Corporation

Field Obs

Above: A ski tour in the Shames Mountain backcountry in NW British Columbia. Unbelievable terrain and great people.

Below: This photo is one of Doug's favorites. It was taken at the Lyell Hut on the Lyell Glacier in the Canadian Rockies just north of Golden BC.

Photos Doug Braumberger

This art, a compilation of pieces by Susan X. Billings, is excepted from a chapbook which is a collection of weather forecasts and haiku of the day produced during the 2014-15 winter for *The Hateful Eight,* a feature film directed by Quentin Tarantino. The filming took place on Lizard Head Pass and Wilson Mesa, near Telluride, Colorado.

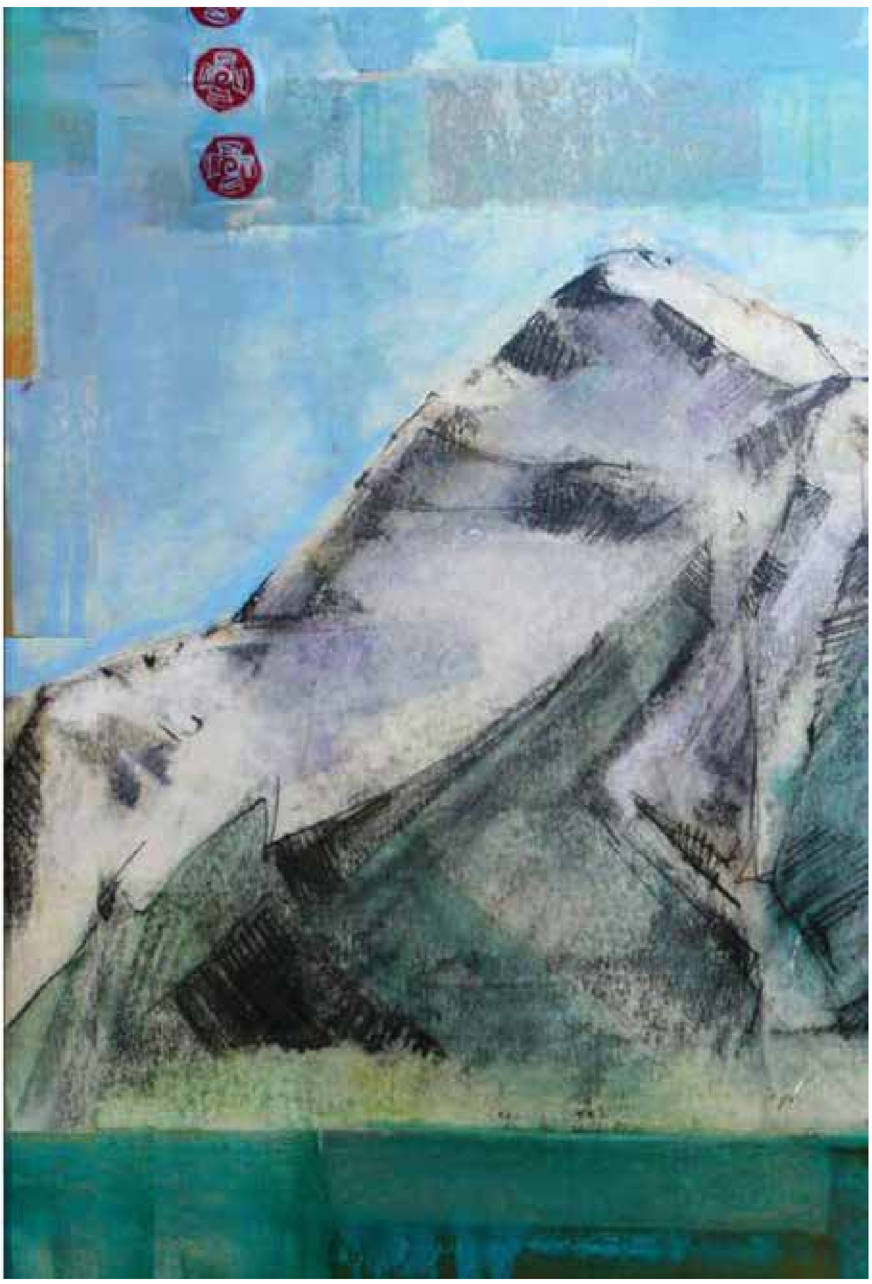
Mountain Weather Masters LLC., Jerry Roberts and Mike Friedman, provided two-a-day forecasts plus hourly updates during storms to help capture atmospheric story points.

Jerry Roberts, Mike Friedman, and Jerry's wife Lisa Issenberg (who did all the hard work) created the chapbook as a gift to executive producer Georgia Kacandes and Quentin Tarantino in honor of good working relations.

Please check out their websites:
susanxbillings.com
mountainweathermasters.com

Just by being
I'm here–
In snow-fall.

ISSA



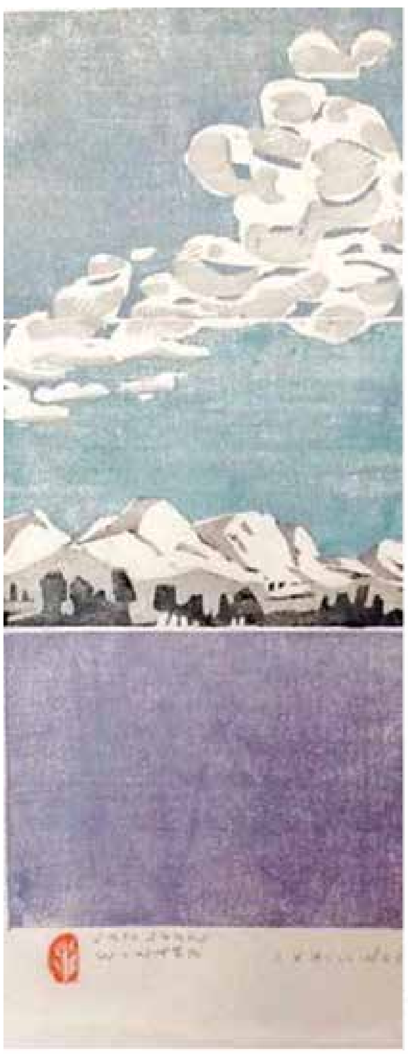
mountain in blue

"For executing critical weather decisions during the filming of Quentin Tarantino's The Hateful Eight, Mountain Weather Masters was my go-to resource. The "Blizzard" was a focal point of the film, and we needed the most accurate forecasts for planning each day's production schedule. They delivered… with style."

— Georgia Kacandes, Executive Producer, The Hateful Eight.

Thinking of retirement
he realizes
he never had a job

JOHN BRANDI (1943-)



san juan winter

NORTHWEST SAN JUAN MOUNTAINS WEATHER FORECAST

MOUNTAIN WEATHER MASTERS

The San Juans are currently between storms with partly cloudy skies and warming temperatures. But by this afternoon, an upper level, low-pressure trough, currently forming in the Great Basin, will move into western Colorado and mix with moisture flowing into the 4-corners from the southwest. Looks like a good storm for the San Juans with potential of 10-15" depending on location/elevation, with SW facing terrain being favored.

As the closed-low forms over the Great Basin, the timing of a frontal passage early Tuesday morning should cause good snow production. The closed-low will sink into Arizona, and depending upon how quickly and how far south it travels will tell the story of precip. rates and snow totals. This storm should be with us through Tuesday evening (but weakening by Tuesday afternoon) as it exits our forecast area.

By Wednesday morning, clearing skies, drier air and high-pressure returns as the flow shifts to the northwest through the weekend. The first chance of another disturbance is Sunday, but it is too far out to be anything but science fiction right now...

SAN JUAN MOUNTAINS	Monday	Monday Night	Tuesday
Temp (F)	20-25	14-18	20-25
Wind Speed (mph)	5-10	10-20	5-15
Wind Direction	SW	SSW	SW
Sky Cover	Overcast	Overcast	Overcast
Snow (in)	0-2	4-8	4-8

COMMENTS:
This storm isn't going to really get going until later this afternoon/evening... but expect increasing cloudiness and scattered snow showers by mid-day. I'd set up for snow storm shots by later afternoon (15:00) and be ready for tomorrow morning's action... storm will begin in earnest tonight through tomorrow morning and then begin it's decline by afternoon.

Schmid Ranch should see more snow activity late in the storm tomorrow as the closed-low will be spinning snow into the north side of the San Juans, with wrap-around moisture as it moves SE, causing wind direction change from SW to NE-NW flow.

SCIENCE CLASS: LESSON 1

TEACHING THINGS PEOPLE DON'T REMEMBER?

BY NANCY PFEIFFER

My first avalanche class as a 17-year-old college student found me lost in a snowstorm of math and science I did not understand. More importantly, it left me fascinated. Teaching avalanche courses in the late '80s, I remember spending entire toe-numbing days in the snow pit looking at a square meter of snow, lost in a minute world of temperature gradients and crystal types. In my nearly thirty years as an avalanche educator I have ridden an interesting swing.

At the 1994 ISSW[1], Doug Fesler and Jill Fredston presented a list of eight variables— things outside of snowpack, weather and terrain— that could be affecting our judgment, and deemed them "human factors." We, as a community, began to accept that unstable snow wasn't the only thing that was killing us. Poor communication, bad group dynamics, and faulty decision-making were also the culprits.

While our understanding of snow has grown significantly in 30 years, the way snow behaves as a material has not actually changed, nor is it likely to change in the future. Snowpack is complicated. Our students don't understand it. Sometimes our instructors don't understand it, and at some level we as humans don't understand it. In my career I have witnessed and participated in a trend de-emphasizing snow science in favor of softer skills at the level-one stage. On the surface this makes sense. We only have a precious 24-30 hours with our students. Why bother teaching people things they don't remember or can't understand?

This is the question I would like to address. In David Lovjoy's 2012 [2] survey, professional avalanche educators identified "the emphasis on snow science principles" as the element of avalanche courses with the greatest discrepancy among course providers.

Here are a few ideas I think we should consider:

Repetition is important in learning. Catherine Snow, an education professor at Harvard University, states that, "In order to have a high probability of learning a word, you need to encounter it fifteen to twenty times." In advertising the term "effective frequency" is used to communicate the number of times a person must be exposed to a message before a response is made, and above which exposure is considered wasteful. Even if students don't "get" some of the more scientific components the first time around, do we owe it to our students to expose them to concepts they may come across in the future in books, an advisory, or talking with friends?

Most people learn better when they understand the why behind the subject. A solid foundation and a common set of building blocks are needed for people to understand complex subjects. Concepts such as creep and glide are needed to help people to understand why avalanches break at convexities, why snow behaves differently at different temperatures.

Experienced avalanche educators have identified one of the biggest changes in avalanche education over the years as being the availability of detailed avalanche forecasts. Quality avalanche forecasting centers are a great tool for our students. However, all forecasts cover a wide area. We need to provide our students with tools to assess slope scale stability. We also need to be cognizant of the fact that not every place has an advisory, so we also need to teach to those who will go outside advisory areas. Or will skiing outside an advisory area become a skill recommended for Pro-Rec graduates only?

Based on my experience, a large percentage of our students come to avalanche class "to learn about snow." Even if group dynamics or good travel techniques turn out to be what ultimately saves their life, do we owe it to our customers to give them what they came for? At the same time, we don't want to tell people they can dig a hole and find out everything they need to know.

Maybe the question we should be asking is: How do we tell our beginning students that, no, they can't base their decision on a snow pit, and, yet snow pits are a valuable tool? As my mentor, Jill Fredston, said, "You have to dig a lot of pits to get to the point where you don't have to dig a lot of pits." While not every instability is obvious in a snow pit, some are. Knowing what is under the surface helps people interpret what their quick traveling tests are telling them.

Understanding snow and recognizing human factors are equally important. As Doug Chabot wrote in the December 2014 *TAR*, [3] "When we stop and dig a few important things happen: we pause, take a breather, come together and look at the snow. Everything slows down. Communication becomes possible again instead of being spread out and checked out with ear buds pushed in."

If we tell students they can't base their decisions on human factors, we need to give them clear alternatives. After all these years as an outdoor educator I still wonder if we can truly teach judgment. The Oscar Wilde quote, "Good judgment comes from experience, experience comes from bad judgment," comes to mind. If we think snowpack is complicated, try the human brain. Maybe the most we can do is to give people a decision-making framework to keep them alive while they develop judgment.

In addition, data suggests that a surprisingly large number of our students do understand the science. A 2006 [4] survey of level-one graduates taken a week after their avalanche course showed a 88% retention rate on all of the material we teach. That in itself is a heartening number. Remarkably, the answers to the snow metamorphism questions got an 87% correct response. Based on a limited sample taken by Hendrikx and Johnson for their 2014 [5] Tracks Project, 50% of level one graduates have a bachelors degree, and almost another 20% have a graduate degree. This matches my personal experience. Our students are educated professionals. I believe they will rise to the level of competence we expect.

It is easy to overdo it and present too much non-key information. Instructors love to talk about the cool thing they saw snow do once, and we should discuss these phenomena — with each other. Our job is to sift out what is meaningful for our students, but let's be careful about eliminating the "hard stuff" just because it's hard. It is our job is to present a complex subject in a simple manner, to relate new concepts to things people already know.

> **GOOD JUDGMENT COMES FROM EXPERIENCE, EXPERIENCE COMES FROM BAD JUDGMENT.**
> **- OSCAR WILDE**

My personal goal is to instill a bit of wonder, to increase people's observational skills and to let people know that this is not the end, but the beginning of their education. Snow is fun and fascinating! It's okay to leave a level one feeling a bit humbled. Hopefully, students will also leave with a better understanding of how snow behaves — most of the time.

I believe we are doing a far better job of educating our students compared to when I was in school. Talking with avalanche educators, I think we agree more than we disagree. I see the current trends in avalanche education — like many learning processes — as a pendulum. I believe we will one day return to our center, a bit wiser for the ride. ▲

REFERENCES

1 *The Human Factor-Lessons for Avalanche Education. Fredston, Fesler, Tremper 1994*

2 *Avalanche Education in the United States: The Good, the Bad and the Ugly. Lovejoy 2012*

3 *Human-Factors and Digging. Chabot TAR 33.3, 2015*

4 *Skill and Knowledge Mastery of Students in Level 1 Avalanche Courses. Pfeiffer, Foley 2006*

5 *Ski/ Sled Tracks as an Expression of Avalanche Risk. Hendrix 2014*

The viewpoints presented in this article are mine alone and are presented as a starting point for a conversation. The opinions in this piece are not necessarily those of any organization or other individual.

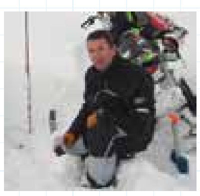
Responses to Nancy

This is a great topic for all of us to be thinking about as we retool our avalanche classes for the upcoming AAA pro/rec split. As an instructor, I agree with Nancy that snow science has a place in introductory avalanche classes. And as one of AIARE's Instructor Trainers, I believe this is in line with the way that other AIARE instructors deliver their classes.

At AIARE instructor trainings this season, many of us are referencing three recent articles on this topic (links provided below): Chris Lundy and Drew Hardesty in Backcountry Mag online, and Doug Chabot's response to Drew. So far it's been generating good conversation. It seems a lot of it boils down to subtle differences in approach, but not dramatic differences in final treatment during classes. Now I'll add Nancy's article to my list on this topic.

There are observations and technical knowledge relevant to a particular day, and observations and technical knowledge that contribute to lifelong learning. I think the more we make that differentiation clear during introductory classes, the less likely we are to have cold and confused students experiencing WTF moments.

— Travis Feist



Travis experienced his first Tahoe snowstorm while on a cross country motorcycle trip, and decided to stick around. He has been working in the snow ever since; as a guide, pro patroller, and now splitting his time as an Observer for the Sierra Avalanche Center, the Training Coordinator for AIARE, and guiding and teaching in South America in the "off" season.

Nancy wrote a great article that I 100% agree with. Just because the snowpack is complicated doesn't mean we should shy away from teaching about it. As we found in our survey of 715 people, mostly MSU students who took our avalanche awareness class with field component, up to two years after the class 86% of the students dug snowpits to influence their decision-making compared with 38% before the class. If you teach people to put a shovel in the snow and test, they'll do it. Everyone has their first pit. I remember mine on a Level 1 on Red Mountain Pass in 1986; a seven-foot snow wall lined with 20 popsicle sticks delineating the layers. It was all WTF. Yes, it's confusing and complicated, but with time it became less so, and that's why it needs to be taught. It's the only way to know what's under our feet, no matter what we're feeling or how we're acting.

— Doug Chabot
Gallatin National Forest Avalanche Center
November 30, 2015

Doug Chabot has been director of the Gallatin National Forest Avalanche Center since 2000. He travels and climbs in Central Asia in the summer months and is co-founder of Iqra Fund, a nonprofit dedicated to helping girls get an education in northern Pakistan.

backcountrymagazine.com/stories/mountain-skills-use-snowpack-tests-to-make-better-decisions/
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www.mtavalanche.com/blog/another-viewpoint-backcountry-magazine-article

SCIENCE CLASS: LESSON 2

ANALYSIS OF UTAH AVALANCHE FATALITIES IN THE MODERN ERA

BY DREW HARDESTY

The Utah Avalanche Center (UAC) has records of Utah avalanche fatalities for the modern era, totaling 114 deaths. The modern era refers to the post-mining decades (the late 1800s and early 1900s) and begins with the first recorded avalanche fatality near Alta, Utah on January 1, 1940. The primary aims of this study were to understand who was getting killed in avalanches, where they were getting killed, and what types of avalanches were killing them. By understanding these factors, and looking at trends over time, we might start to better understand how to forecast, educate, and otherwise influence the decision making of winter backcountry recreationists in Utah. As with any papers looking at statistics, it might be tempting to look at these fatalities as just numbers. But at the end of the day, each incident is not a number at all. Each incident is a human being, a person with a family and a community, with dreams and aspirations whose life was taken from them by an avalanche.

1. INTRODUCTION

Avalanches pose significant risk to the backcountry traveler in the winter environment and have been responsible for 114 recorded deaths since the winter of 1939/1940. The Forest Service Utah Avalanche Center was founded in the spring of 1980 and began issuing daily avalanche bulletins the winter of 1980/1981 in an effort to "keep people on top of the greatest snow on earth instead of buried beneath it." The Utah Avalanche Center issues danger ratings with special emphasis on Avalanche Problems, their aspect, elevation, likelihood, size, and trend. By looking at the data to determine trends and patterns, we might gauge not only how well the Utah Avalanche Center has warned about the danger, but what improvements might be made in the future.

2. METHODS

Utah is located in the central Rocky Mountains of North America and is characterized by an intermountain snow climate and is known for abundant snowfall, moderate temperatures, and excellent winter backcountry recreation. Data used for this study was gathered via Snowy Torrents accident reports, the Center for Snow Science at Alta, and (often typed or hand-written) records maintained by the Utah Avalanche Center. Methods in gathering the data for the categories are as described below.

2.1 Danger Ratings

The earliest avalanche forecast centers, based in Seattle, Washington and Boulder Colorado began issuing danger ratings on a 4-point scale (Low, Moderate, High, Extreme). The term "Considerable" was added to the danger scale for the winter 1996/1997 in an effort to better describe what was then referred to as "Moderate to High danger". In 2010/2011, the danger scale was amended to reflect travel recommendations as well as likelihood of triggering and expected size. Each avalanche center issues a single word Bottom Line to depict the overall danger for the day, however the Utah Avalanche Center (and others) have often spatially and temporally segregated the day's danger, often with the use of "pockets" of the next higher danger rating. In this study, I "rounded up" pockets to the next higher danger level while defaulting to the highest danger rating on a day where the danger was segregated. For this study, I utilized the Bottom Line danger rating for the day and in some cases extrapolated a High danger rating for the day when an Avalanche Warning was issued. A few are Unknown. NR refers to No Rating. These include years prior to the creation of the Utah Avalanche Center in 80/81 or when a rating was not issued for that region or day.

2.2 Assigning Avalanche Problems

After the Utah Avalanche Center began issuing avalanche advisories with info-graphic – supported Avalanche Problems in 2005/2006, the format has been widely adopted around the world. Since then, the newly "coined" Avalanche Problems have become central to any discussion of the avalanche phenomenon among practitioners and educators. The Avalanche Problems have included location (aspect/elevation), likelihood of triggering, expected size, and forecasted trend. Following up on the UAC's work, the Colorado Avalanche and Information Center published forecaster guidelines for assigning and grouping the avalanche problems. For a study looking at avalanche fatalities 1998/1999-2012/2013, the CAIC developed additional criteria to assign avalanche problems, and these criteria can be found in Appendix A. As avalanches were not formally described by Avalanche Problem prior to 2005, I combed through the reports to determine the failure plane, fracture line depth, and snowpack history and retro-actively assigned an Avalanche Problem name for each incident.

3. RESULTS

3.1 Fatalities by Year

With 114 fatalities since January 01, 1940, Utah averages 1.5 deaths/year. Utah averaged 2.1 deaths/year from 1985/1986-1994/1995; 4 deaths/year from 1995/1996-2004/2005; and 3.3 deaths/year from 2005/2006-2014/2015, with a 30 year running average of 3.13 deaths/year. While there have never been definitive studies that look at the growth of user days by backcountry recreationists, significant growth may be implied through backcountry gear sales numbers and personal observation.

3.2 Avalanche Fatalities by Region

Until the mid-1990s, the great majority of avalanche deaths occurred in the greater Wasatch range, as access and interest may have been greatest out of Salt Lake City, Park City, Ogden and Provo. There may also be some correlation with proximity to ski areas with 22 of the total 114 avalanche deaths stemming from access into either out of bounds terrain within or adjacent to the ski area. Figure 2 gives an overall view of the proportion of avalanche fatalities by the seven regions as partitioned and forecasted for by the Utah Avalanche Center (Logan, Ogden, Salt Lake City, Provo, Uintas, Skyline, and La Sals). Figure 3 depicts trends over the last 30 years and clearly shows that the Uintas and Skyline areas have become regions of significant and growing avalanche activity. The table below shows trends over the past three decades per region. Whereas the Uintas and the Skyline accounted for 0% of the fatalities from 1985/86-1994/1995, they accounted for nearly 30% of the fatalities from 1995/1996-2014/2015. Fatalities out of Ogden, Salt Lake, Park City, and Provo have accounted for just over 57% of the total over the same time period. While Logan accounts for only six fatalities, it's worth noting that there the Logan forecaster continues to investigate increasing

UTAH AVALANCHE FATALITIES BY REGION FOR THE PAST THREE DECADES

	1986/87 - 1994/95	1995/96 - 2004/05	2005/06 - 2014/15
LOGAN:	1	3	2
OGDEN:	2	4	5
SLC/PC:	12	18	10
PROVO:	2	5	2
UINTAS:	0	5	8
SKYLINE:	0	5	5
LA SALS:	4	0	1

numbers of close calls and severe accidents just across the Idaho border in the Caribou-Targhee National Forest. The La Sals suffered an incident in the spring of 1992 that killed four people, including the avalanche forecaster for that region.

3.3 Avalanche Fatalities by User Group

Figure 4 depicts the proportion of avalanche fatalities by user group (skier/snowboarder, snowshoer, snowmobiler, and other (camper, foot, climber, etc). With the lone exception of a snowboarder fatality in upper Big Cottonwood Canyon of the central Wasatch Range in February of 1986, all of the avalanche fatalities until 1994/1995 involved backcountry or "side-country" skiers or those on foot (hiker, etc). Figure 5 depicts the trends of user group fatalities from the past three decades as well as the winters spanning 1939/40-1984/85. Over the past twenty years, snowmobilers have overtaken skiers as the user group with the most fatalities. There is a strong correlation between user group and region and it should be noted that snowmobile use is prohibited in many parts of the Salt Lake City portions of the Wasatch due to water quality concerns. The mid 90s is when long tracks and mountain-specific sleds came out and there was a corresponding jump in snowmobile avalanche fatalities.

It should be noted again that 22 of the total 114 avalanche deaths stemmed from access into either out of bounds terrain within or adjacent to the ski area – and these data trends are noted in Figure 6. As almost 1 in 5 fatalities are from recreationists leaving the ski area to enter either closed terrain or out of bounds terrain (sometimes called "sidecountry" terrain), they may be of a different mind-set and experience than those that begin their outing from a trailhead. The data does not reflect inbounds fatalities or pre-season fatalities prior to the resort being open for the winter.

3.4 Avalanche Fatalities by Aspect

It did not come as a surprise that most fatalities occur on the northerly facing slopes. Northwest through north through northeast facing slopes held just over 75% of the fatalities while terrain above 9500' (upper elevation band) accounted for more (54%) than the mid and low elevations combined. Snow quality is of the highest quality on these aspects and it's no coincidence that ski resorts are built with this in mind. Aspect also plays a role in relation to sun and wind, which, in turn, plays a role in the type of Avalanche Problem one may encounter. The table at right illustrates the proportion of avalanche fatalities by aspect while Figure 7 does so in a graphical manner.

3.5 Avalanche Fatalities by Elevation

While recreational elevations in the winter environment range from 4500' in the foothills above towns and municipalities to over 13,500' on King's Peak in the Uinta's, most backcountry winter recreation occurs between 8000' and 11,000'. The Utah Avalanche Center issues danger ratings for separate elevation bands for the three bands noted on the following page in Figure 8.

UTAH AVALANCHE FATALITIES 1940-2015

BY YEAR

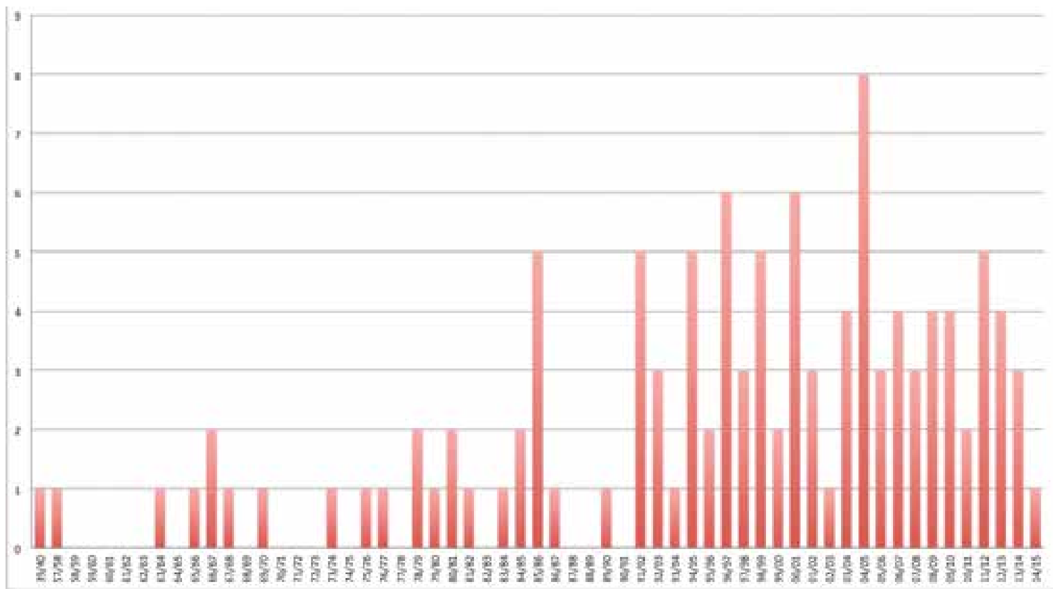


FIGURE 1

BY REGION

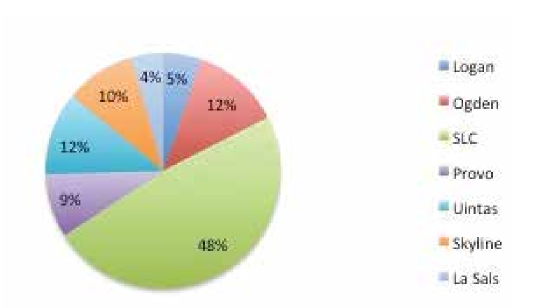


FIGURE 2

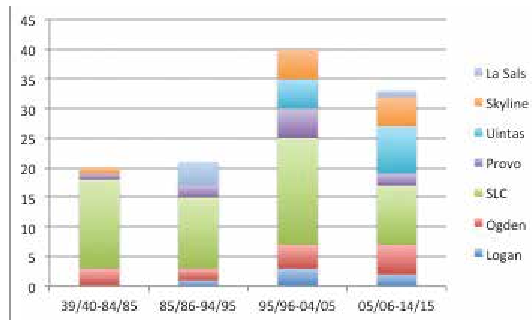


FIGURE 3

BY USER GROUP

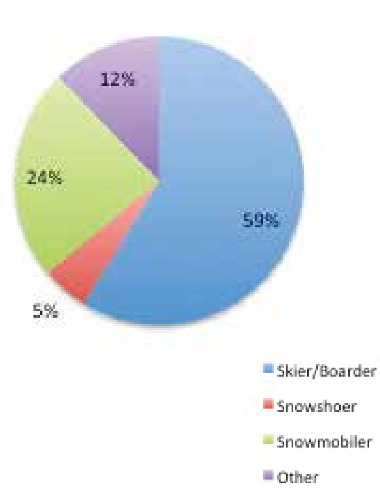


FIGURE 4

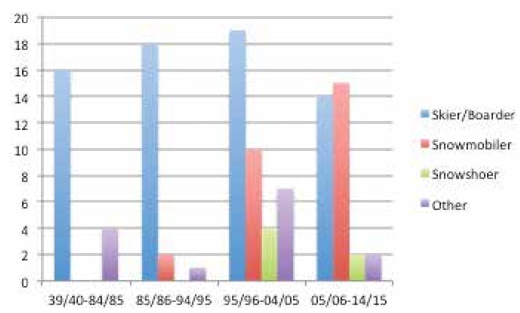


FIGURE 5

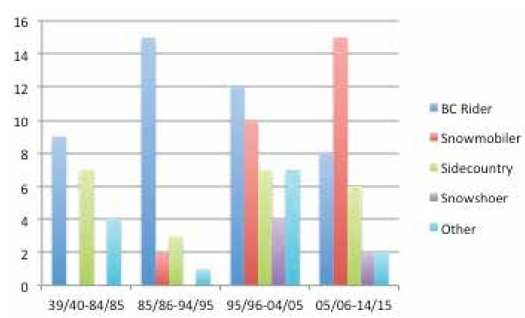


FIGURE 6

BY ASPECT

FIGURE 7

North: 26
Northeast: 42
East: 11
Southeast: 6
South: 2
Southwest: 3
West: 4
Northwest: 14
Unknown: 6

UTAH AVALANCHE FATALITIES 1940-2015

BY ELEVATION

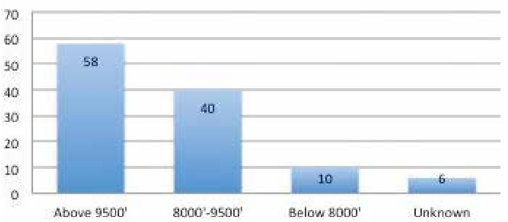


FIGURE 8

BY DANGER RATING(1996/97 - 2015)

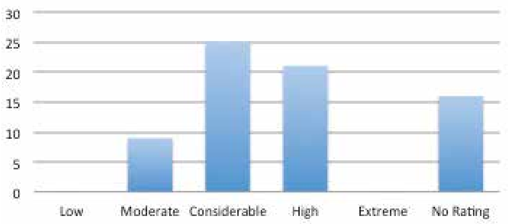


FIGURE 9

BY AVALANCHE PROBLEM

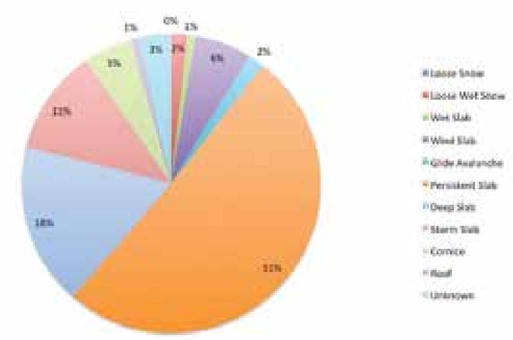


FIGURE 10

BY DANGER AND PROBLEM

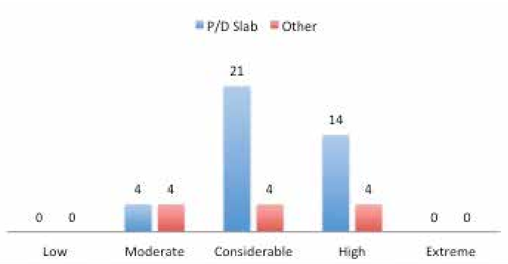


FIGURE 11

3.6 Avalanche Fatalities by Danger

As the term Considerable was not added until the 96/97 winter, fatalities by danger rating for this study begin in that year. Utah has recorded 71 avalanche fatalities since then. Zero fatalities were recorded during Low or Extreme danger ratings, while Moderate, Considerable, and High account for 16%, 45%, and 38%, respectively, on days when a bottom line rating was provided. For 16 fatalities, no rating was given for the day (typically early season or on "off days" in the outlying areas). See Figure 9.

3.7 Avalanche Fatalities by Avalanche Problem

Beyond issuing an overall danger rating, the Utah Avalanche Center further details the expected Avalanche Problem(s) the winter backcountry user is expected to find. Each Avalanche Problem is then further described and rated for aspect and elevation, likelihood, size, and trend. One of the main goals of this study was to look at which Avalanche Problems contributed to more deaths than others. In other words, which Avalanche Problem(s) might be construed as "more lethal" than others. Surface hoar, faceted grains, and depth hoar played a role in most fatalities and this is best represented by the sheer numbers in the Persistent and Deep Slab categories. Figure 10 shows them in proportion to one another. Snow cascading off a roof in Midway, Utah in January 1995 comprises the lone roof-a-lanche in Utah. The two fatalities in Stairs Gulch of Big Cottonwood Canyon on April 28, 2001 may be the only reported glide avalanche deaths in the United States. Cornice fall resulted in the fatalities of six individuals. In each case, the weight of the victim(s) and cornice subsequently triggered another avalanche on the slope; however, for the purposes of this study, they were categorized as Cornice Fall.

3.8 Avalanche Fatalities by Danger Rating and Avalanche Problem

Human triggered avalanches on persistent weak layers may be triggered days, weeks, even months after they formed while the danger for triggering avalanches on non-persistent weak layers my diminish to zero over the matter of a few hours to a few days. As such, persistent weak layers (noted here by Persistent and Deep Slab avalanches) may carry a Moderate (L2) danger long after they have been buried and widely reactive. Part of this study was to look at the proportion of Avalanche Problems that resulted in fatalities per danger rating. For this analysis, I grouped Persistent and Deep Slab avalanches together in one group while putting everything else into the other group. For this study, I included Cornice Fall into the Other category regardless of subsequent avalanching. See Figure 11.

CONCLUSIONS

In this study, I investigated the reported 114 avalanche fatalities in Utah for the modern era; that is, fatalities in the post-industrial era and attributed to recreation in the winter environment. Not surprisingly, the Wasatch Front areas (Ogden, Salt Lake City, Park City, and Provo) make up 69% of the fatalities since 1940. Still, the trends are unmistakable, as one can clearly see a growing population recreating in the Uintas and the Skyline, terrain responsible for almost one-third of the fatalities over the past 30 years. While skiers and snowboarders comprise two-thirds of the fatalities since 1940, over the past 20 years alone, snowmobilers account for just over one-third of all avalanche related deaths. Nearly one in five fatalities involve people going into closed or out of bounds terrain from one of the mountain resorts.

In summary, while backcountry recreation continues its explosive growth in the Utah winter environment, it appears that the number of avalanche fatalities has plateaued over the past decade. While most fatalities involve backcountry skiers in the mountains east of the Wasatch front, the highest upward trends involve snowmobilers in the Uinta and Skyline areas. Continued outreach and education to these user groups in these areas – as well as improved teaching and forecasting for Persistent and Deep Slab avalanche problems may well reduce the numbers of accidents and fatalities in the coming years. ▲

Appendix A: Avalanche Problems

Deep Persistent Slab (DS):

- *Persistent weak layer of either faceted grains or depth hoar*
- *Average crown of 1.2 m (4 ft) or greater*
- *Destructive size of D3 or greater. Estimated destructive potential for broken trees gathered via reports.*

Persistent Slab (PS):

- *Persistent weak layer of surface hoar, faceted grains, or depth hoar, or bed surface in old snow (O)*
- *Average crown of 4 feet (1.2m) or less*
- *Destructive size of 2 or 2.5. Estimated destructive potential for broken trees gathered via reports.*

Storm Slab (SS):

- *Bed surface in recent storm snow (S) or at the new/old snow interface (I)*
- *Accident investigator described Storm Slab*

Wind Slab (WIND):

- *Bed surface in recent storm snow (S) or at the new/old snow interface (I)*
- *Accident investigator described Wind Slab*
- *Photographs showed characteristic lens shape of Wind Slabs*

Wet Loose (WL):

- *Snow was moist or wet*
- *Did not release as a cohesive slab*

Wet Slab (WET):

- *Snow was moist or wet in the starting zone*
- *Released as cohesive slab*

Glide (G):

- *Released as wet, cohesive slab*
- *Released on the ground*

Cornice Fall Avalanches (C):

- *Failure of overhanging masses of snow*

Roof (ROOF):

- *Occurred on the roof of a structure*
- *Bed surface was the structure*

Unknown (U) avalanches:

- *Lack of data prevented us from coding into one of the above avalanche problems*

Field Obs

Unknown snowboarder causing a slide on “The Beast” On the Shuskan Arm in the Mt. Baker Ski Area Backcountry.
Photo Grant Gunderson

SCIENCE CLASS: LESSON 3

THE ROLE OF COLLAPSE IN AVALANCHE RELEASE:

REVIEW AND IMPLICATIONS FOR PRACTITIONERS AND FUTURE RESEARCH

BY NED BAIR, PH.D.UNIVERSITY OF CALIFORNIA – SANTA BARBARA

INTRODUCTION

Reports of collapses and *whumpfing* sounds and their links to instability in the snowpack have been around for decades, but like many areas of snow science, they have received limited scientific treatment. There is a consensus that shear fracture plays an important role in the avalanche process, but the role of collapse is still disputed.

REVIEW

Roch (1956) discusses the role of collapse in the failure process, saying that this phenomena occurs when the slope normal (perpendicular) weight of the slab exceeds the slope parallel weight, and is accompanied by an onomatopoeic whumpf. Bradley (1966) hypothesizes that deep slab avalanches are caused when the crushing strength of a weak layer is exceeded, resulting in a vertical drop that initiates the avalanche *(Figure 1)*.

Truman (1973) recounts triggering collapse waves in snow on flat ground and estimates the waves traveled at 6 m sec-1. Truman also mentions that waves were reflected back at the observer on several occasions after hitting bare patches. Perla (1974) discusses different failure scenarios, including a thin (without collapse) and thick (with collapse) weak layer and cautions the reader that there may be no single unifying failure mechanism. Interestingly, Perla (1971; 1977) was the first to note that avalanche crown faces are nearly always perpendicular (± 10°) to the bed surface which has been cited numerous times (e.g. McClung, 2005; McClung and Schweizer, 2006) as compelling evidence that the primary failure occurs in shear. The reasoning is that avalanche crowns form at the bed surface, where tension is highest because the slab is sliding due to the failed weak layer, and travel towards the snow surface.

McClung (1981) was the first to apply modern fracture mechanical concepts to avalanches, including elastic (recoverable) energy from the slab driving crack formation from flaws (small cracks) in the snowpack. He adapted a model for slope failure of soils (Palmer and Rice, 1973) to snow avalanches. In this model, *strain softening*–decreasing strength with increasing deformation–occurs in the weak layer and drives shear crack formation. In this model, the *critical length*–the crack length required for self-propagation–decreases with increasing slope angle, meaning that less force is required to trigger an avalanche as slope angle increases. In this model, the critical length becomes infinite for 0∞, meaning that shear cracks cannot propagate on flat ground. The minimum angle for shear fracture is 20-30°, called the *friction angle* (van Herwijnen and Heierli, 2009; Reiweger et al., 2015). A slope angle dependence for the primary failure has been adopted in many avalanche fracture mechanical models since (e.g. Gubler and Bader, 1989; Louchet et al., 2002; Chiaia et al., 2008; Gaume et al., 2014). McClung dismisses collapse as a failure mode, at least in naturally-triggered avalanches, by noting that slow compressive deformation of the snowpack, i.e. conditions caused by loading during a storm, cause strain hardening–the opposite of strain softening–and strengthen the weak layer (McClung, 1981). Under rapid compressive loading, i.e. an artificially-triggered avalanche, McClung (1981; 2011) maintains that a dynamic shear fracture would cut through the weak layer and that any resulting collapse would be in response to damage caused by the shear crack.

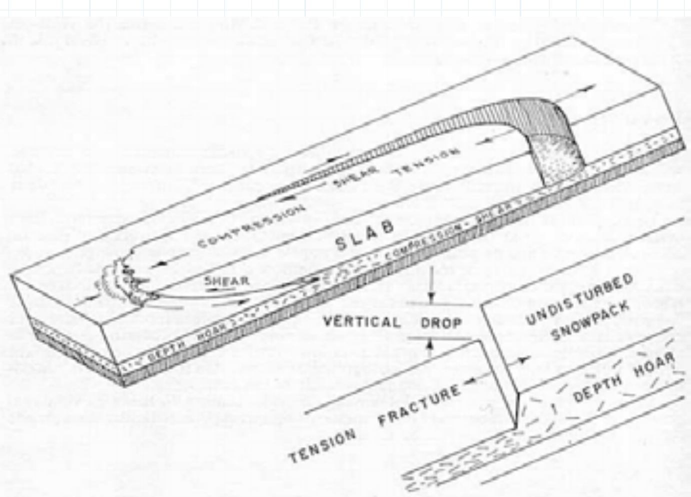


FIGURE 1: An early depiction of collapse in an avalanche. *Reprinted from Bradley (1966).*

There was a revival in scientific study of collapse models beginning with Johnson (2001) as an effort to explain remote triggering of avalanches from flat ground, where shear cracks cannot propagate. Most notably, the collapse of a buried surface hoar layer on flat ground was measured with a string of geophones. The collapse wave speed was measured at 20 m sec[1] (Johnson et al., 2004). Johnson (2001) developed a mathematical model that describes a flexural wave propagating through a slab. This model was adapted and improved mathematically by Heierli (2008). Using terminology to describe compressive fractures in sandstone (Fletcher and Pollard, 1981), the term *anticrack* was employed to describe collapse fracture, in this case in snow. For short cracks, the anticrack model predicts that the mechanical energy of the crack will be nearly independent of slope angle. This formulation has helped to explain results from Propagation Saw Tests (PSTs, Sigrist and Schweizer, 2007; Gauthier and Jamieson, 2008) that show critical cut lengths having little relation to slope angle. Similar results–test scores that barely change with slope angle–have been documented in Extended Column Tests (ECT, Simenhois and Birkeland, 2009) both on persistent (Heierli et al., 2011) and non-persistent (Bair et al., 2012) weak layers. Recently, the Compression Test (CT) was also shown to exhibit little change in score with changing slope angle (Birkeland et al., 2014a), contrary to results from an earlier study (Jamieson, 1999).

For longer cracks, the anticrack model envisions a shear fracture with *fracture energy* (a measure of weak layer strength) that is reduced by the collapse of the slab. Thus, the anticrack model can be generalized to a case of zero collapse, in which case it reduces to a very similar form as the shear model proposed by McClung (1981). In the anticrack model, the weak layer failure is decoupled from the sliding of the slab; that is the initial weak layer failure has little dependence on slope angle, but whether or not the slab then slides downhill depends on the friction angle. As with most avalanche fracture mechanical work, Heierli (2008) concentrates on the sub-critical (not self-propagating) and critical (self-propagating) phases of crack growth. Fracture arrest is mentioned briefly, but no model is provided.

The strong bending phase in collapse models has led to the suggestion that crown fractures initiate at the snow surface and travel towards the bed (van Herwijnen, 2005; Gauthier and Jamieson, 2010) since, in these models, tension in the slab is greatest at the snow surface. These crown fractures can arrest weak layer fractures. *En echelon* (French for ladder rung) slab cracks are parallel and equally-spaced cracks that appear on the surface of the slab prior to the crown in a minority of avalanches. *En echelon* cracks have been cited as evidence

[1] A crack is the void created between two surfaces while fracture is a process that creates the crack. These definitions have been reiterated before (Simenhois and Birkeland, 2011), but continued mistakes (myself included) warrant another mention.

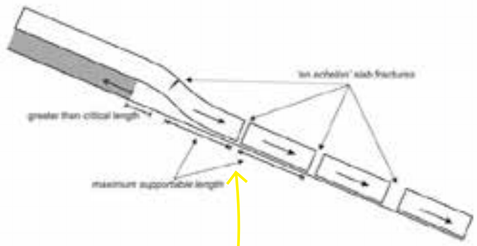


FIGURE 2: Schematic of a weak layer crack winning the race against *en echelon* cracks. The weak layer crack propagates because the distance from the front of the collapse wave to the slab fracture exceeds the critical length. Note the furthest uphill *en echelon* crack forming at the snow surface and traveling down towards the weak layer. *Reprinted from Gauthier and Jamieson (2010).*

of a race *(Figure 2)* between fracture in the weak layer and fracture in the slab, with the distance between the front of the collapse wave and the *en echelon* crack governing whether the weak layer fracture propagates or arrests. Specifically, this distance must exceed the critical length.

Evidence for the anticrack model has also been shown in particle tracking analysis of stability tests. For instance, collapse of a weak layer has been documented in hundreds of tests, including CTs (van Herwijnen, 2005), rutschblocks (van Herwijnen, 2005), ECTs (van Herwijnen and Birkeland, 2014), and PSTs (van Herwijnen et al., 2010). Notably, in ECTs and PSTs, collapse began directly under the loaded area and propagated across the beam. Further, ECTs showed no displacement in the weak layer throughout the slab prior to failure (van Herwijnen and Birkeland, 2014). Likewise, buried pressure transducers showed negligible stress opposite the loaded ends of ECTs prior to failure (Thumlert and Jamieson, 2015). This evidence suggests that failure occurs as a sudden fracture rather than from progressive damage to the weak layer, as is suggested by strain softening theories (e.g. McClung, 1979). Collapse wave amplitudes are mostly in the 1-10 mm range with wave speeds 10-40 m sec-1, with the wave speed showing a positive relationship with collapse amplitude and slab density (van Herwijnen and Birkeland, 2014). Videos of PSTs show no evidence of a sharp shear crack ahead of the collapse front (van Herwijnen et al., 2010), which would be expected if collapse followed shear in these tests (e.g. McClung, 2011) .

In contrast, particle tracking has also been used to show that, prior to failure, shear strain (displacement) dominated over compressive strain in small-scale laboratory tests on samples with weak layers of surface hoar (Reiweger and Schweizer, 2010) and depth hoar (Reiweger and Schweizer, 2013). Likewise, sample strength decreased with increasing slope angle, opposite the findings in the larger-sized field tests mentioned previously and in support of shear models. Yet, the snow samples in these experiments still fractured on flat and low angle (0-20°) slopes, where the load is mostly compressive. To account for the compressive failure of snow below the friction angle, which is not accounted for in shear models, various approaches have been suggested. One approach is a Mohr-Coloumb-Cap model (Reiweger et al., 2015). The Mohr-Coloumb-Cap model has slope angle dependence for triggering on slopes steeper than the friction angle. For slopes below the friction angle, the "Cap" is added which allows for compressive failure of the weak layer and is not dependent on slope angle. Another approach has been to suggest that during artificially-triggered collapse, such as is modeled by the PST, high strain rate and mixed-mode (compressive and shear) loading conditions are present and create sufficient slope parallel slip to drive propagating shear fractures (McClung, 2009; McClung, 2011). It is suggested that fracture cannot be naturally-triggered on low angle or 0° slopes because of insufficient slope parallel slip (McClung, 2011), but this suggestion has not been tested.

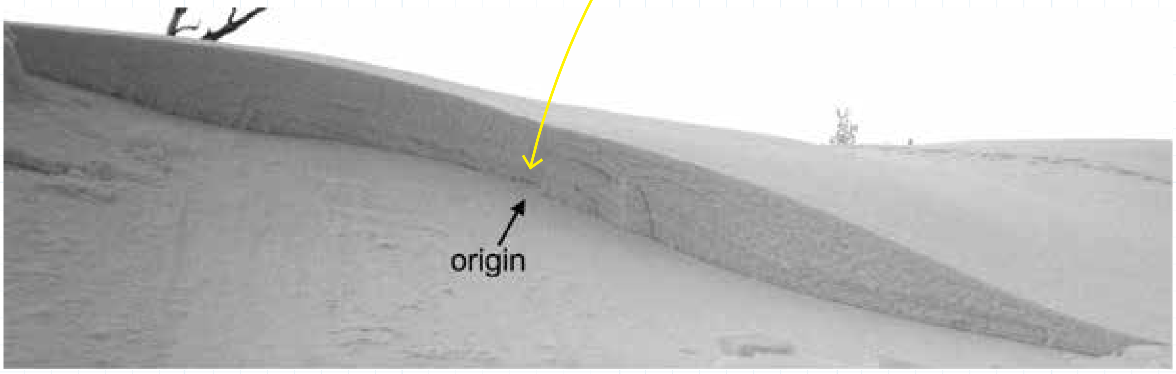
Recent work with longer PSTs and ECTs (≥ 2 m) has shown some intriguing findings, as longer tests are required to reduce edge effects (Bair et al., 2014) and to allow for slab fracture in harder slabs (Gaume et al., 2015). In these longer tests, the importance of the bending of the slab in the failure process was highlighted by Birkeland et al. (2014b) who were only able to arrest fracture in PSTs after inserting 30 cm long artificial supports (plastic binders) into the weak layer *(Figure 3)*. Supports in the weak layer < 30 cm in length did not arrest fracture, nor did removing sections of the weak layer. The authors hypothesized that these measures should have successfully arrested a sharp shear crack by increasing the fracture toughness of the material (transition from snow to plastic binders), or by blunting the crack tip (transition from snow to void). The authors suggest that these results show that a propagating collapse wave, not a shear crack, was driving the failures. Another explanation is that shear fracture preceded collapse and that the slab was able to bridge the stress at the crack–tip; in other words, the slab allowed the crack to jump over the supports < 30 cm in length (Gaume et al., 2014).

Yet, even with longer tests, there is an undeniable difference between the failures in these small scale tests and slope scale avalanches. For example, I have not witnessed or found evidence in the literature of a crack that traveled further than 7 m in an elongated ECT or PST (Bair et al., 2014). Given that cracks travel much further in avalanches, these stability tests are missing something. One possibility for the difference is that fractures in these tests are restricted to straight-ahead propagation while fractures in an avalanche likely travel radially. Also, these longer tests seem to be disconnected from stability as they are likely to yield high false stable rates (Bair et al., 2015) and are therefore not recommended for stability assessment.

FIGURE 3: 30 cm long plastic supports inserted into the weak layer to arrest fracture in a PST. *Reprinted from Birkeland et al. (2014b).*

CONCLUSION

The debate continues, but it is becoming apparent that fracture models that do not account for collapse of the weak layer on low angle slopes are incomplete. As a material, snow is weak and full of flaws (Michot and Kirchner, 2002) and capable of both collapse and shear failure on flat and steep slopes. To understand more about the role of collapse in avalanches, we need high resolution and precise measurements of displacements in the slab and weak layers during failure. Such measurements are logistically difficult, but not impossible, to make. One possible finding from such measurements may be that collapse plays a prominent role near the trigger, but diminishes as the failed area expands. For example, stability tests show the importance of collapse near the trigger, but there is less evidence of collapse at the perimeter of large avalanches. Distinctive *river* (also called *plumose,* Gauthier, 2012) markings from near-infrared images taken at crown faces indicate that crown fractures originate at the bed and travel upwards towards the snow surface. Such markings support the notion that failure at the crown is in pure shear, suggesting that bending plays a minor or nonexistent role, at least at the crown.



Theoretical implications aside, these slope angle/stability test score relationships have an important take home for practitioners. The take home message is that in many circumstances, but not all, stability tests can be conducted in terrain that is not steep enough (i.e. < 25∞) to avalanche (Birkeland et al., 2010; Birkeland et al., 2014a). We know now that stability tests will yield similar scores independent of slope angle. The "not all circumstances" is that the snowpack must remain the same throughout the slope angles tested. For instance, if the slab is twice as thick (measured slope normal) in the steeper terrain, then this take home message will not hold up. Additionally, these collapse models highlight anecdotal evidence on remote triggering from flat ground, which has been observed in all types of snowpacks, from those with thick depth hoar layers to non-persistent weak layers (Johnson, 2001; Heierli, 2008; Bair, 2012). Again, regardless of the theoretical implications, it's advisable for practitioners to fully recognize remote triggering potential and be aware of runout zones when traveling on flat or low angle terrain.

Newer stability tests, such as the ECT and PST, highlight the importance of collapse in crack propagation, but fall short of reproducing the avalanche failure process because of inherent edge effects. For instance, standard 0.9 m ECTs have shown high false alarm rates (a measure of incorrect unstable predictions, Ross, 2010; Bair et al., 2015) and standard length PSTs, especially for hard slabs, may not be long enough to allow for slab fracture (Gaume et al., 2015), which might cause false alarms. Yet, longer ECTs are less accurate overall and suffer from dangerously high false stable rates (Bair et al., 2015). The best stability tests have come from practitioners and I hope that this article will motivate further thought and discussion on improving these tests. ▲

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I thank Ron Perla and Karl Birkeland for vetting this article. I gratefully acknowledge Johan Gaume for his detailed review. Last, I thank Lynne Wolfe and Larry Heywood for motivating me to write it.

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Above: Dry fracture faces, Alta. Shows propagation up from the bed.

Below: Peter Lev at Alta. This image shows fracture but no release induced by explosives. Note the radial curve and propagation into trees, Fracture people are not giving enough attention to "pin points" and crown"clamping ."

Photos and comments from Ron Perla.

Below: He believed in collapse. Charles Bradley and his resistograph.

Below: Wet glide at Alta. This is a better example of up propagation (as are many bell shaped crevasses.)

SCIENCE CLASS: LESSON 4

FROM THEORY TO PRACTICE: FRACTURE TO FIELD

BY BILL ANDERSON

How fracture theory applies to the field practitioner. Wow... this is a can of worms. In order to wade into this fray, I'll need to define generally how the landscape of my mind works in order to attempt to make this make sense.

First off, we need to understand that Science is a very mean game. In this 'game' you never get to win, as it is only a matter of time until you get proven wrong. It's just how it is, you will be shown inaccurate, incorrect or just plain off base. Theories are designed to be tested so that their strengths and weaknesses can be understood -otherwise they aren't theories. I shy away from good sounding ideas that can't be tested, because these ideas don't leave room for themselves to grow. There is an upside to creating a really good theory however, and this is that your theory may get to become a law if it holds up long enough. It's unlikely that you will come up with that good of theory, but the idea of discovering a new piece in the puzzle is worth the inevitable change in how things are understood.

A couple of laws that come to my mind are from to greats in our history. Isaac Newton with the laws of motion and gravity, and Robert Hooke who's laws govern springs, with work and energy stored therein. The Young's Modulus of a material, a key component of Anticrack Theory, is in fact effectively a Hooke's law consequence (as Dr Physics would say). I'd recommend Googling Dr. Physics Youtube video on Hooke's Law and Youngs Modulus if you are trying to wade through the more core side of fracture theory -it's an excellent review.

The reason I set my intro into this idea of how scientific process is driven, is so that as we talk about the theories that govern fracture (attempting to apply them in practical decision-making) we understand the need to allow fluidity in our thought process as we as a community further understand what is in fact happening.

Basal facets topped by wind slab made for a sensitive combination as Mark White and Mark Staples triggered Radar Love Bowl remotely from the ridgeline on December 17, 2015.
Photo Mark White

Because the practitioner has no choice but to apply ideas that are based on theories. We attack the process from a variety of points of view, and hopefully from a cup of knowledge that is first steeped in humility. Fracture theory for us will come into play in the subset of data referred to as Category 2.

When dealing with snowpack and avalanche information, we look at three classes or categories of data.

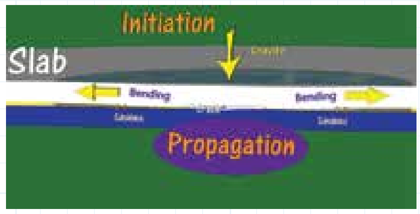
Category 1 data (in some circles called bull's eye data) refers to obvious signs of instability. Avalanche activity, collapsing and cracking in the snowpack are the main data points being screened for. In general the lifespan of these observations is about 24-48 hours. A notable exception to this are the deep or persistent problems which may linger for weeks or months and in some cases the lifespan of a snowpack. In effect, the logic behind Category 1 observations runs something like, "Hey, there are avalanches happening there, and because here looks like there I should be wary..." This is a pretty common sense approach to things and a simple way to know when to back down on terrain. These sorts of observations are key components of decision making and become very difficult to work with in the case of the deep or persistent problems because they present far less frequently in the season.

Category 3 information is effectively weather data and speaks well to the fact that the most common slides are direct action avalanches. So if you think "More snow equals more avalanches" then you get the gist of how Category 3 data will play. In addition, if you consider that the weather is the primary architect of the snowpack, the process of maintaining as much relevant weather history as possible will help you stay in touch with the likely processes occurring in the snow.

Now on to Category 2 data. This category employs the rather dark arts of snow science. It can roughly be broken into two classes of information. The first is taxonomy, the second is fracture potential.

A QUICK WORD ON TAXONOMY:

As a community we know a lot about grain types, and how they are formed has been well studied over time. As building blocks, these grains form the stratigraphy of the snowpack -the laminate structure if you will. Wrapping your mind around



the structure of the snowpack is the first step to finding the clues as to where your problems lie.

NOW ON TO FRACTURE:

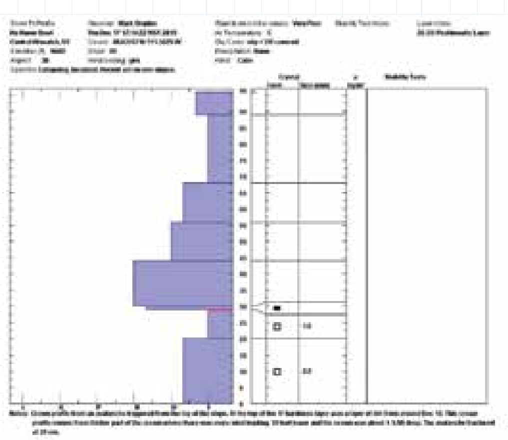
Hopefully by now it's clear that this sort of observation is a subset of the overall picture that a practitioner is attempting to paint.

Fracture, as a process is somewhat irreverent to the grain/ layered makeup of the snowpack. It requires only two things. The first is a layer within the snowpack which could be restructured into a tighter packing order. In plain English this is a weak layer. The key component here is that the grain to grain bond structure of this layer is arranged so as to be more porous than the slab above, and as well, these grain to grain bonds are more easily broken than in the slab above. The end game is that once this layer is destroyed the slab will have displaced downwards as the weak layer grains are now stored in a lower volume or thinner layer. When you consider the porous nature of snow, basically any grain in the snowpack might serve as a weak layer grain type. It really has more to do with the weak layer's relationship with the overlying snow that counts.

The second component of fracture is the slab. At the end of the fracture process, the end product is the production of the slab! Prior to that, the slab is just a laminated part of the snowpack. So in the beginning there are some properties that this would-be slab must have. The main property which the slab must fulfill is to be able to elastically hold itself together in a way that it can stress the weak layer below.

Imagine a weak layer that is barely holding up under the stress of the snow above it. Now an extra bit of stress is placed in a small area as a skier or rider moves onto it. This extra stress pushes that layer to its breaking point. This could be the start of the fracture process if the slab can maintain its structural integrity as it tries to span this area of broken weak layer. The broken weak layer area is called a crack. It sounds funny to call it that, because you can't see the broken weak layer like you would in something like your windshield, but nonetheless that's how it's labeled. As the span of this new 'crack' is enlarged by the skier's/rider's mass, it may get to some critical size where the skiers/riders mass is no longer needed to break the weak layer and only the mass of the slab is required. This is what is called the critical crack size (or crack length) and this results in propagation of the weak layer's breakdown.

Remotely triggered by skiers walking the ridgeline. Fracture propagated well over 1000 feet triggering two or three avalanches that were separated by snow that did not move for some reason.
See profile below by UAC Director Mark Staples from same event.
Photo Mark White



The result of this relationship between the slab and the weak layer is that a non linear collapse wave can ripple through the snowpack, leaving in its wake a delaminated slab. So at its completion, if the fracture process occurs on a slope that is steep enough, the slab simply slides down and thus an avalanche.

Much of this theory is driven by the Laws of Gravity and Hook's Law derivatives, so it is, in concept, easy to understand. It has also been shown to be testable to a degree using regular video cameras and little black markers to measure very subtle differences in the movement of slabs created in longish isolated column tests. From this evidence, there is one slight problem, which is that the mathematics from the theory doesn't quite describe all of the empirical data from field observations. This is a pesky little detail but quite important unfortunately.

The natural question is whether to modify the mathematics of the theory, modify the concept slightly, or assume the theory incorrect. Right now it seems like first two options are where most of the efforts are being placed.

The question then for the practitioner is how to cobble all of this stuff together into a coherent action plan?

PRACTICAL PROCESS:

The most important thing to remember is that we as humans miss things all the time. We are not as observant as we think we are. This means that your ability to appropriately gather those critical Category 1 clues is inherently flawed. It's a one way street unfortunately, in that if you DO see signs of instability then you know it's unstable, however if you DON'T see activity or feel any collapsing you have to assume that you didn't look hard enough. There is nothing fair about that I know -it's just reality.

Once I decide to dig into the snowpack I see it as an attempt once again to look hard enough. After a general outline of the snow structure, the next step is to product an Extended Column Test (ECT). It's the easiest and fastest test you can perform (think two probes and a knotted cord). This test is simple to interpret. If your taps produce fracture across the entire column you have a problem. Don't get hung up on Q values or fracture characteristics: you have two separate pieces of a column of snow where you once had one. It really is that simple. You've also found the missing collapse that you didn't observe otherwise during the day. Fracture in pit tests is a Category 1 data point in my opinion.

This is a key distinction, and really the point of this entire piece. **Observation of propagation, which is technically demonstrating fracture potential, needs to be considered in the same way that collapsing is considered.** Once again, beware of the idea of explaining these results away nonchalantly. Certainly, the idea of saying that the theory is still incomplete and as such these results are misleading would be ill advised at best.

For the advanced practitioner, you may have some options to interpret your results. Your biggest enemy here is the concept of motivated reasoning. I'd recommend that you really know the difference between a wind and storm slab before you decide to declare a propagation result invalid based on its location on a slope... Don't ever forget that premise that we miss things all the time.

What if you did not produce fracture in your ECT? The ECT is the best test for sniffing out fracture potential if you don't know the layer of concern, but it is destructive as you are tapping and destroying about a third of the column. With soft snow and or deep instabilities the ECT can miss things. As I type this, I'm working in a snowpack that during the height of its last cycle was not producing consistent ECT results. I switched to the Propagation Saw Test (PST). In a test pit with no ECT result, I was able to define two separate layers with PST 25/165end results. These also represent Category 1 results -just like whoomfing on the skin track.

Right about now, most seasoned practitioners should be ready to point out that there are times when you see propagation results in test pits for days or even weeks before you see the eventual cycle. The fear is to miss all of that good skiing and riding! This does happen, especially with PWLs and deep cycles you can see the writing on the wall long before the events begin. It's frustrating.

Keep in mind what I just proposed though. I'm suggesting that when you observe propagation (fracture) in your test pits that you would be wise to weigh that result as though you just experienced a collapse, as a Category 1 bulls-eye piece of information. Especially, as these layers get buried more deeply in the snowpack.

Personally, I resolve that there may be some seasons where some lines just aren't good ideas. Yup, all season. This sort of thing happens to surfers all the time right? So you're not alone in the waiting game at least. It's just that what you are seeing is harder to see than a wave. The flip side is that some years it's game on for much of the season!

An old climbing partner once told me that the mountains will always be there, and the trick is making sure that you are. ▲

First Aid

AVALANCHE VICTIM TRAUMA; EVIDENCE-BASED RECOMMENDATIONS

BY MARTIN I. RADWIN, M.D.

Avalanche Victim Trauma

INTRODUCTION

The unmistakable contribution of trauma to mortality and morbidity during avalanche accidents, although clearly overshadowed by asphyxiation as the predominant cause of death, has in the last several years been an area of considerable academic interest in the medical literature around the world. The extensive data derived from several studies demonstrate that trauma accounts for less than 25% of avalanche deaths, ranging widely depending on regional differences as will be discussed.[1 2 3 4 5 6 7 8 9] Basic recommendations supported by the literature are presented and graded using the scheme of the American College of Chest Physicians[19] and are applicable to anyone exposed to avalanche terrain *(See Table)*.

GEOGRAPHIC VARIABILITY AND MORTALITY

The mortality statistics relating to avalanche trauma appear to vary significantly with geographic location around the world and the particular characteristic terrain endogenous to the region over which an avalanche victim slides; such as in heavily forested regions in western Canada compared to those predominated by open bowls as in Europe or the western United States.[10]

An early study by Grossman and colleagues,[2] methodologically weakened by the use of mixed data that included both partial and complete burials in Utah and several regions of Europe, reported that traumatic injuries occurred among 25% of the survivors of avalanche accidents. As many injuries in survivors remain unreported, this is almost certainly an underestimate. The most common injuries were major orthopedic, soft-tissue, and craniofacial injuries although chest contusions and rib fractures were reported in some survivors. The overall mortality from multiple trauma in the relatively small Utah series was 16%.

However, a recent demonstration of the concept of "geographic variability" as it relates to avalanche survival was revealed during a comprehensive medical examiner review of full-burial survival patterns in Canada compared to an updated Swiss dataset over the same 25-year period using similar statistical methodology (Switzerland n=946 vs. Canada n=301).[7] Haegeli et al. found no difference in overall survival between the two countries (46.2% in Canada, 46.9% in Switzerland).[7] However, the Canadian survival curve, although of similarly four-phased morphology as seen in the Swiss data set, was characterized by an earlier and more rapid drop in survival in the initial "Survival Phase" of burial (after only 10 minutes) despite a statistically significant faster extrication time in Canada *(Figure 1)*. As expected, trauma accounted for more than half of the deaths among victims extricated in the first 10 minutes. The study also showed (not surprisingly) that two-thirds of the trauma-related deaths involved collision with trees. Overall trauma-related deaths in Canada were 18.9% as compared to studies in Europe and the U.S. with rates as low as 5.6% in Austria as determined by internal/external autopsy[8] and 5.4% in Utah using similar methodology.[3] All of the non-asphyxial deaths in this study were attributed to blunt trauma.[3] As shown in these studies, the use of formal internal/external autopsy is critical in the determination of cause of death.

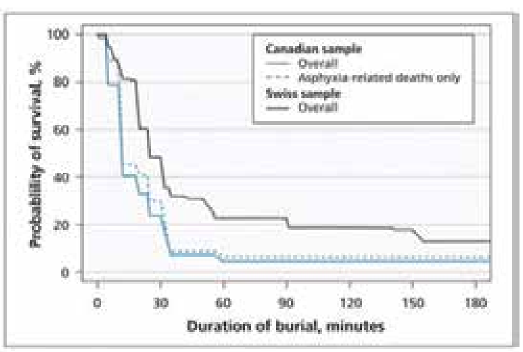


FIGURE 1: A comparison of the Swiss avalanche survival curve (black line) and the Canadian survival curve (blue line) over the same 25-year period. Note the rapid drop after 10 minutes in the Canadian curve although still maintaining the same morphologic survival phases. (From Haegeli et al., 2011[7]) .

Recommendation:

Avalanche trauma mortality statistics in the medical literature should only include studies performed in which the cause of death is established by extensive external and radiographic examination or ideally the standard full autopsy.[7] (Grade: 1A) Studies using other than this methodology should be statistically disregarded.

The geographic differences in endemic terrain features, as previously noted, likely dictate the differences in trauma rates discovered between countries and regions, although this remains an area of continued research and could possibly involve other factors. The contribution of such unknown variables to regional trauma rates, such as: the long-term prevalent use of air bag systems in Europe compared to North America, mechanized approaches to remote backcountry skiing and snowboarding in Canada, the prevalence of helmet usage and the notable absence of snowmobiling in Europe are unknown but deserve further research.

Recommendation:

Although the practice of wearing helmets is strongly recommended for anyone recreating or working in avalanche terrain, their use would appear even more critical in wooded terrain. (Grade 1B)

MECHANISM OF INJURY

Avalanche victims can sustain virtually any type of traumatic injury during their often-turbulent descent in the momentum of an avalanche, and certainly if involved in collision with trees,and rocks or cliff falls.

Hohlrieder and colleagues[8] reviewed the injuries of 105 avalanche victims in Austria and noted a high incidence of chest trauma, lower-leg fractures, and shoulder dislocations. The orthopedic injuries were felt likely related to attached skis and poles causing mechanical leverage on the extremities although the high rate of chest trauma in this region of low trauma mortality is unexplained. Additionally, spinal fractures were found in as many as 7% of the cohort questioning whether these fractures could actually occur pre-burial during turbulent flow and not always by collision with an object.

Johnson and colleagues[9] reviewed autopsy reports from 28 avalanche deaths in Utah over a 7-year period looking specifically at closed head injury (CHI). Among 22 avalanche victims who died from asphyxiation, one-half experienced mild or moderate traumatic brain injury (TBI), which the authors argued could cause a depressed level of consciousness and contribute to death from asphyxiation. In this study as many as 61% of the victims had evidence of CHI. This important category of combined trauma and asphyxia, since it may be difficult to determine the primary cause, must be considered in studies on the pathophysiology of death in avalanche. All six of the avalanche deaths that were felt to be primarily the result of trauma involved severe traumatic brain injury.

In another review of 56 avalanche fatalities in Utah, all three deaths that were determined to be due solely to trauma involved evidence of head injury.[3]

Recommendation:

These data again strongly argue for the routine use of helmets in avalanche terrain. Education about the primary prevention of head trauma by the use of helmets in avalanche terrain should be emphasized (Grade 1B).

Although the data presented clearly demonstrate the role of head and brain injury during avalanche accidents, in the Hohlrieder study[8] it is noted that the only two solely traumatic deaths (5.6%) in their series were caused by isolated fracture and dislocation of the cervical spine; possibly revealing the remarkable forces that an avalanche can apply to the human body[4] and in particular the vulnerability of the cervical spine.

Recommendation:

Since the head and neck appear to be the cause of much traumatic mortality during avalanche accidents, rescuers must adhere to stringent neck stabilization techniques after head exposure, if possible, during even the most difficult of extrications. (Grade1B).

Long bone fractures should be stabilized and immobilized as best as possible to prevent pain, blood loss, worsening shock or hypothermia, which is always present to some extent in buried avalanche victims.

Potential spine injuries should be treated with common mountain medicine techniques and by following other locally published recommendations including management of potential head injuries and spine fractures. (Grade 1C)

PROTECTIVE GEAR

Protective gear has the potential to limit the extent of trauma from an avalanche accident. In addition to the routine use of a helmet, an avalanche airbag, which specifically has a shape designed to reduce trauma to the head, neck, and chest during collision with objects *(Figure 2)*, may have promise. However, there is negligible meaningful data presently available and with several balloon configurations on the market, prospective comparisons regarding trauma prevention efficacy are difficult. Further research and validation is absolutely required before recommending the use of this device to reduce the risk of head, neck and torso trauma.

GRADE OF RECOMMENDATION	QUALITY OF SUPPORTING EVIDENCE
1A. Strong recommendation, high quality evidence	Consistent evidence from well performed randomized, controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
1B. Strong recommendation, moderate quality evidence	Evidence from randomized, controlled trials with important limitations (inconsistent results, methodological flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.
1C. Strong recommendation, low quality evidence	Evidence from observational studies, unsystematic clinical experience, or from randomized, controlled trials with serious flaws. Any estimate of effect is uncertain.
2A. Weak recommendation, high quality evidence	Consistent evidence from well performed randomized, controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
2B. Weak recommendation, moderate quality evidence	Evidence from randomized, controlled trials with important limitations (inconsistent results, methodological flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.
2C. Weak recommendation, low quality evidence	Evidence from observational studies, unsystematic clinical experience, or from randomized, controlled trials with serious flaws. Any estimate of effect is uncertain.

FIGURE 2: An example of one particular avalanche airbag system configuration being deployed that may theoretically show promise against head, neck and chest trauma.

Recommendation:

No adequate evidence exists at this time supporting some avalanche air bag system manufacturer's claims of head, neck or chest protection from a balloon device, although this is an imperative area of further research. (Grade: 2C)

TRAUMATIC CARDIAC ARREST

The chances of survival with traumatic cardiac arrest in an avalanche setting are exceedingly low, but may be considered possible if a fast and efficient chain of survival is available.[13-15] However, to date no survivor with traumatic cardiac arrest from an avalanche accident has been reported. If CPR is initiated, it may be discontinued after 20 minutes if no response is observed unless there is a strong suspicion of a polytraumatic hypothermic etiology necessitating transport to a facility with cardiopulmonary bypass for rewarming.

Recommendation:

In an avalanche traumatic cardiac arrest victim consider starting CPR only if highly efficient ground or Helicopter EMS (HEMS) transport is available; otherwise strongly contemplate withholding or not continuing CPR as dictated by local, national, and international guidelines.[17,18] (Grade 1B)

Summary

Traumatic injuries account for the second highest cause of death in avalanche accidents, and although variable rates are noted regionally in the literature, asphyxiation has been well shown to be the predominant lethal mechanism worldwide. Non-lethal trauma is probably much higher than the reported 25% in survivors as many don't seek medical attention and remain unreported. Although long bone orthopedic injuries are not surprisingly common, the often-violent mechanism of injury during avalanche travel and collision has been shown to be associated with a significant rate of head, neck, and chest injury. At this time, preventive equipment that can be confidently recommended is a helmet. Further research will be needed to assess the efficacy of certain avalanche airbags in the prevention of head and neck injury. Initiation of CPR in a traumatic arrest victim, unless possibly consistent with a hypothermic etiology and a clear airway, can be attempted for 20 minutes and ceased if unsuccessful or in such situations where HEMS or rapid ground transportation is unavailable, never started. ▲

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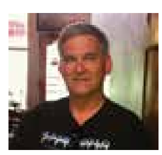
Martin I. Radwin, M.D., a professional member of the AAA for almost 20 years, has combined much of his professional medical research and a passion for snow and avalanche science, to better understanding avalanche victim pathophysiology and translating that knowledge into improved survival devices. Well-published in this area, he was an early member of the team investigating the efficacy of the AvaLung that further studied respiratory physiology and hypothermia in buried victims. An international lecturer, long time WMS member and lecturer and former member and lecturer for the Weber County Sheriff's SAR mountain rescue team, he lives, skis, and practices medicine in the Salt Lake City area.



First Aid

STILL NOT DEAD YET . . .

BY TERRY O'CONNOR MD, AJ WHEELER MD, ALICIA PETERSON MD

16:30pm. The ranger station is still. The storm clouds are clearing. Inside, the rolling glow of embers fade in the fireplace, as outside, the amber alpenglow lights the fresh coat of snow on the mountain above.

A knock on the door breaks the silence.

"Hey are you a Ranger?, I just snowshoed down from Panorama Point. When the clouds cleared I saw a single set of ski tracks ending in an avalanche path below the Paradise Glacier. I didn't see any ski tracks out"

Looking out to the parking lot, you see a single car, out of state plates, coated in the last few cm of today's storm snow. A sticker is still visible on the rear view window . . . ' No friends on powder days. ' A single set of footprints leads to a skin track with a single set of pole plants. Damn.

You place a call the SAR coordinator.

In the last episode of 'Not Dead Yet' (*TAR* 33.3, February 2015) we challenged the assumption that all prolonged burials or delayed rescue attempts are inevitable body recoveries. In reviewing the latest data and survival curves we were reminded that indeed the best chance of recovery occurs within the first thirty minutes of burial, as most victims succumb to either trauma or asphyxiation within this window. However, in review of our most robust avalanche survival data set to date, we discovered that burial over a half hour does not necessarily mean 0% chance of survival, but perhaps anywhere from 5-20% chance of survival. These are the victims slowly succumbing to the insidious impacts of hypothermia, lack of oxygen, and accumulation of carbon dioxide.

Now, knowing that all prolonged burial victims still deserve our sense of urgency in response, we will dig a bit deeper into how we determine who actually has a chance, how to identify them, and what we can do to give them the best chance possible. It turns out that some of those who we recover looking dead, may not be dead yet.

17:00pm. Signal search has led you and the hasty team to the toe of the slide overlying the creek bed. A ski pole sticks out bent over in the loose blocky debris. Your probe finds a soft thud instead of frozen earth.

Digging down through the loose debris you find a young skier, ***unresponsive,*** *head dangling into the open moat of the creek bed below,* ***mouth free of snow****. As you slowly uncover his body you find no obvious gross bleeding, no gross deformities, clothing cold and drenched, his chest under his jacket* ***feels cool to touch*** *with your ungloved hand.*

Your partner can't feel a pulse and he starts CPR. You break the SAR coordinators conversation with helicopter ops for emergency traffic. Comm patches you into med control. Before you can start with your assessment, and ask what to do, the doctor interrupts . . .

'Did he have an airway? How long was he buried? Does he feel cold?'

This fall at the inaugural Wyoming Snow and Avalanche Workshop, Wilderness Medicine Fellow Dr. Alicia Peterson presented the latest guidelines drafted by the International Commission on Alpine Rescue (ICAR). Our goal is not to replicate her review here, but to highlight the key game changing principals in avalanche victim resuscitation that have been born out of latest medical research.

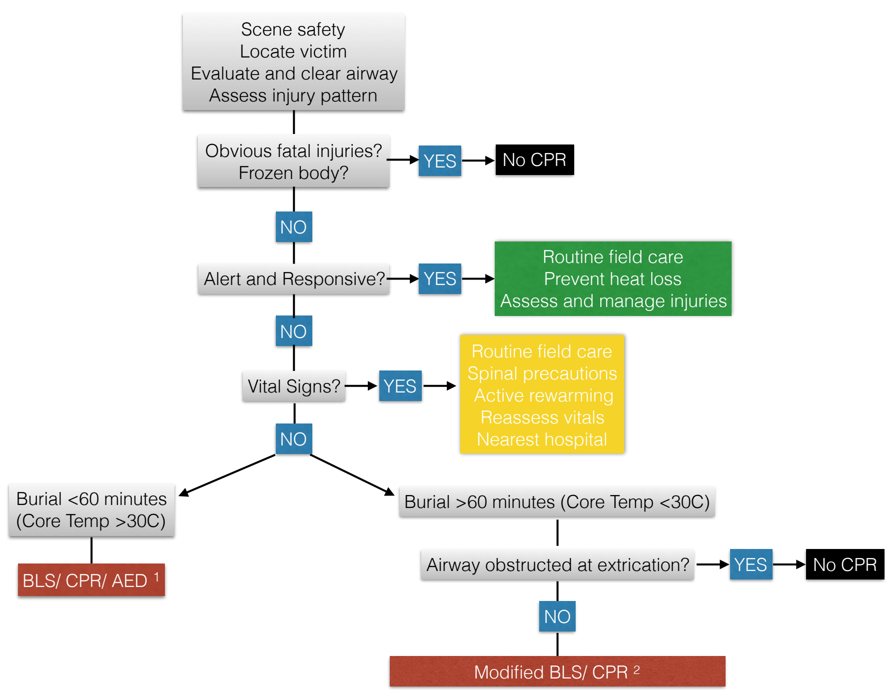
OUR JOB IN TREATING THE AVALANCHE VICTIM WHO APPEARS DEAD WITHOUT VITAL SIGNS IS TO IDENTIFY THOSE WHO MAY LOOK 'DEAD' BECAUSE OF HYPOTHERMIA AND ADJUST OUR TREATMENT PLAN ACCORDINGLY.

The savvy consumer will have also noticed that the ICAR protocols include more sophisticated metrics and interventions that are not common in our typical North American austere medical rescue settings. Here our first line of rescue is often a WFR, EMT, or paramedic without the resources of a physician on helicopter.

We have recognized an audience hungry for a review of the key salient changes, so we propose a simplified algorithm for your perusal for now. We'll step back to our scenario to help hit the highlights that are the foundation for the ICAR guidelines.

Let's first review what has not changed. Speed in locating the victim and clearing the airway, tempered by an assessment of scene safety still comes first and is paramount. This should, of course, not be a surprise as we have just reviewed the best chance of survival occurs within the first 15-30 minute window. Also, the 'obviously dead' (i.e. decapitation, frozen) are still obviously dead. In addition, the walking wounded (those who are alert with vital signs who can tell you what hurts and what is wrong) still receive standard care. That is, to protect from further heat loss, assess and manage injuries in your trauma survey and transport to appropriate care.

The main change to the decision tree is to identify who may benefit from prolonged CPR and why.



Avalanche Rescue Algorithm. 1 Routine CPR care for cardiac arrest as recommended by American Heart Association. 2 Modified hypothermia cardiac arrest treatment.

Avalanche Rescue is dynamic and complicated enough. In the case of the prolonged burial victim how do we decide who is really dead, and perhaps who is not quite dead yet?

Our job in treating the avalanche victim who appears dead without vital signs is to identify those who may look 'dead' because of hypothermia and adjust our treatment plan accordingly.

Now back to our case to help clarify this. In the scene size up the ranger found no obvious signs of trauma incompatible with life. Nor was the patient one of the 'walking wounded', as he was unconscious and unresponsive. His partner could not find a pulse, the patient appeared 'dead', and so he appropriately started CPR.

Medical control asked whether patient had a patent airway and air pocket, because a buried patient will first succumb to asphyxia well before hypothermia if unable to breathe.

Medical control then asked how long the victim had been buried and if he felt cold. Why is 60 minutes important? Based on research, the quickest an avalanche victim could reach a temperature cold enough to result in cardiac arrest due to hypothermia (roughly 30-32C) is 35 min with the majority taking 60min or more. This may occur faster in special circumstances such as cold water immersion. In addition a body that feels warm to touch is unlikely to have had hypothermic arrest.

Most importantly, the current medical literature supports that only those buried more than 60 minutes have had successful resuscitation from hypothermic arrest.

So if we have excluded death from obvious trauma, if a patent airway was identified on extrication, if the patient's core feels cold, if he was buried for more than 60 minutes, or if we can confirm a core temp < 30C is it possible our patient without vital signs looks 'dead' because he got severely hypothermic? Yes it is. Now why does that matter?

It matters because the latest medical literature is replete with evidence of individuals who have cardiopulmonary arrest due to hypothermia and survive to full neurologic function despite prolonged recovery times and even delayed CPR. If your scene size up can support the case that your victim may be dead because he got too cold then some modifications in basic life support and CPR measures are warranted and acceptable.

Severe hypothermia can be thought of as a state of suspended animation. This state is reflected in some abnormal or absent vital signs. Viable heart rates could be as low as just a few a minute so pulse checks should last up to 60 seconds. The heart tissue at low temperatures is extremely susceptible to arrhythmias and cardiac arrest so premature chest compressions should be avoided and all patients handled gently.

If cardiac arrest does occur the body can sustain an exceptional amount of insult due to its metabolic hibernation. With normal body temperatures, CPR is often terminated after 30 minutes of resuscitative efforts if all lifesaving maneuvers have been exhausted. Whereas individuals in hypothermic arrest have survived cardiac arrest lasting up to 8 hours.

In field rescue situations, continuous CPR may not be feasible or safe for first responders. It is also impossible to deliver high quality manual CPR for prolonged periods of time. Therefore, mechanical CPR devices are highly recommended in these situations if available. If mechanical devices are not available, there is a body of evidence gathered from hypothermia induced cardiac procedures and field case reports showing intermittent CPR in patients undergoing cardiac arrest after hypothermia, may be acceptable and life saving. Current recommendations suggest that those with a core temperature <28C can receive 5 minutes of CPR followed by <5 minutes of pause in CPR. Those with a core temperature <20C can receive alternating 5 min continuous CPR and <10 min pause in CPR.

Termination of CPR efforts in hypothermic arrest cases rarely occurs in the field. Severely hypothermic patients ultimately require transfer to a medical facility that can perform rapid rewarming, typically through use of cardiopulmonary bypass technologies before defibrillation efforts are successful or before medical direction can definitively terminate resuscitation efforts.

MODIFIED CPR FOR HYPOTHERMIC ARREST

Adopted when chance of hypothermic arrest (burial > 60 min, core temp < 30C)

1. Check for pulse over 60 seconds
2. Avoid CPR even if only a few beats per min
3. Interruptions in compressions acceptable if necessary for extrication

If Core Temp < 28 C then 5 minute CPR, 5 minute pause
If Core Temp < 20 C then 5 minute CPR, 10 minute pause
If Core Temp < 20 C then avoid multiple attempts at defibrillation

Medical control unlikely to terminate CPR in field

17:20pm. Medical control advocated for prolonged CPR efforts given chance of hypothermic arrest. You recheck for a pulse over a full minute interval and confirm need to continue CPR. An AED is attached and shock is advised. Initial defibrillation attempt is successful, but patient loses pulse again within a few minutes of movement. You understand patient will likely need cardiopulmonary bypass rewarming before successful defibrillation and confirm helicopter is planning on delivery to appropriate facility. You allow for occasional pauses up to five minutes in CPR to facilitate the technical components of transfer as you perform a low angle lower to the LZ.

En route to hospital flight nursing staff intubates patient. An esophageal temperature probe is placed confirming core temp of 28C so no further defibrillation efforts are pursued. Two interosseous lines are placed and warm IV fluids are initiated. CPR continues. Flight nurse staff calls ahead to hospital to ready the cardiac team for emergent rewarming bypass.

The next day the flight nurse calls you back with follow up. Patient was rewarmed and afterwards converted out of ventricular fibrillation with return of spontaneous circulation. This morning he's sitting upright eating eggs for breakfast acting normally. His only complaint is chest pain, . . . probably a result of the three hours of CPR.

THE TAKE HOME

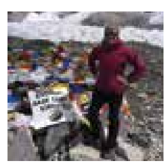
Cardiac Arrest + burial ≤ 60 min: NO hypothermic cardiac arrest = **CPR + ALS for 20 mins**

Cardiac Arrest + burial > 60 min + airway: suspect hypothermia = **modified CPR acceptable**

Burial > 60 min + airway blocked: improbable survival = **NO CPR**

Dr Terry O'Connor is an Emergency Medicine physician in Sun Valley, ID. He is the EMS Medical Director for the Sawtooth Region and Sun Valley Ski Patrol. He previously lived the lives of a ski patroller, NPS climbing ranger, high altitude researcher and expedition physician. In that time he has cataloged an overindulgent amount of aprés ski canned beer with forecaster friends. The fates continue to conspire to place him in the pages of *The Avalanche Review*.

Dr. AJ Wheeler is an Emergency Medicine physician practicing in Jackson, Wyoming. He currently is the Co-Medical Director of Grand Teton National Park EMS , Bridger Teton National Forest EMS and Teton County Search and Rescue, of which he is also an active member



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AAA GRANT RECIPIENT REPORTS

OVERNIGHT SURFACE HOAR FORMATION IN SMALL MEADOW OPENINGS

BY MATT WIELAND

Surface hoar can be a very tricky persistent weak layer to deal with. It can produce avalanches weeks after burial and its distribution is sometimes highly variable at a variety of spatial scales. While the meteorological conditions that are conducive for surface hoar formation are relatively well understood, knowing when these conditions occur at an individual slope is difficult to determine. Additionally, after initial growth and prior to burial, surface hoar may be pushed over, reduced in size, or completely destroyed by elements such as skiers, avalanches, solar radiation, wind, or rain. However, these destructive forces may not occur prior to burial and variability, if any, is introduced strictly during formation.

To help aid in slope-scale evaluations of surface hoar when conditions prior to burial are unknown, studies have related environmental proxies such as skyview and shading to surface hoar crystal size at the surface or weak layer height once buried (e.g. Shea, 2011; Lutz and Birkeland, 2011). By identifying effective environmental proxies that lead to surface hoar variability on individual slopes, backcountry users gain an improved capacity in hazard evaluations for a buried surface hoar layer.

This study examines the relationships between slope-scale vegetation cover, shading, and solar radiation with surface hoar crystal size at two meadows for several formation events. It also describes the slope-scale spatial patterns of surface hoar crystal size across each meadow for these events.

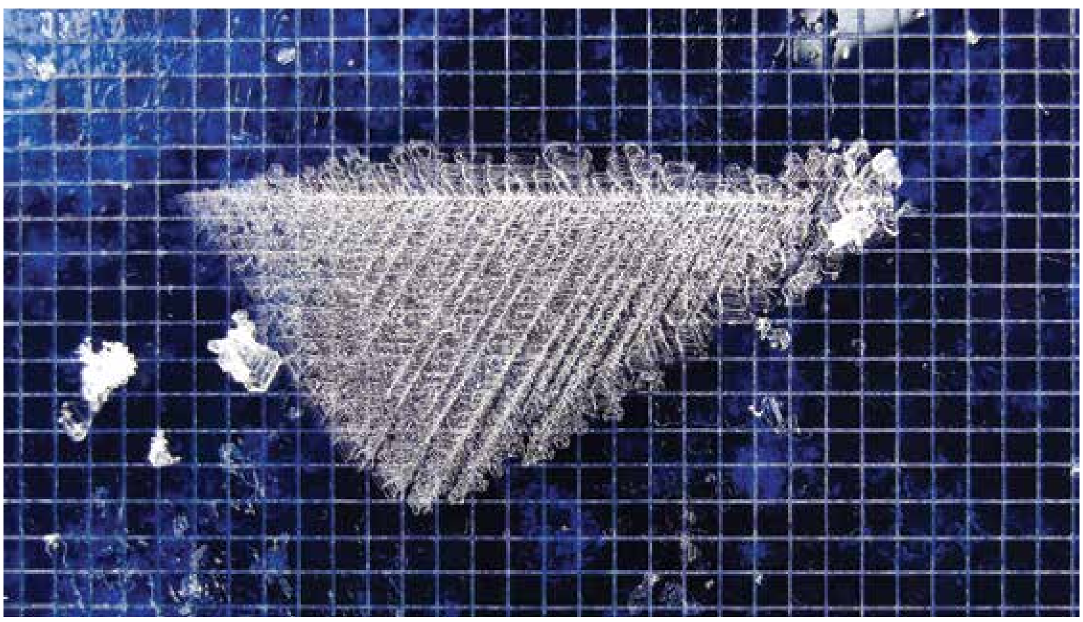
I collected data during the winters of 2013/2014 and 2014/2015 at a north and south study site in the Taylor Fork area in southwestern Montana. The sites are small meadow openings (~ 45 m x 45 m) that lie near the head of two small drainages. The meadows are not in avalanche terrain, have an average winter slope angle of 12°, and are relatively uniform. I collected data for three overnight surface hoar formation periods; two in January and one April. One hundred samples of surface hoar crystal size were collected across each study slope for each event *(see photo)*. Skyview, shading, and radiation estimates for each sample point were derived using hemispheric fisheye photography and compared to three crystal size measures (mean, 90th percentile, and maximum crystal size). Spatial patterns of crystal size were described using spherical semi-variograms.

Scatterplots and Spearman rank-order correlation coefficients indicate few trends or significant correlations. Scatterplots show weak trends between crystal size and skyview at the south site for both January events. All sizing measures for the January 2014 event at the south site show significant negative correlations with shading and radiation estimates. Significant positive correlations with skyview and all sizing measures are found for one January event at the south site. No significant correlations at the north site are found for any event or at the south site for the April event.

Regression analyses also find few significant relationships between crystal size and skyview, shading, or radiation. However, multiple linear regressions using skyview coupled with shading or radiation produce significant associations for most cases. Regression trees show similar results with larger surface hoar associated with areas that possess a larger skyview and are more shaded. Relationships between surface hoar size and environmental metrics for an event did vary between sites, and these relationships changed between events. For meadow openings that experience direct solar radiation during the winter, the sole use of sky visibility for the determination of crystal size may not always be adequate, regardless of the amount of snow covering the surrounding trees. A careful evaluation of areas that are shaded but also possess a high sky visibility is helpful in determining surface hoar size. The strong influence of longwave radiation, which is difficult to estimate in the field, should not be ruled out. Areas that are near solar affected trees may contain smaller surface hoar and must be given special consideration. Also, the influence of solar radiation should not strictly be constrained to examinations into the destruction of surface hoar. While persistence of surface hoar may be greater in shaded areas, this effect may be exaggerated as these areas initially grew larger crystals.

The spatial structure of surface hoar crystal size varied depending on the size measure, event, and location. Spatial autocorrelation lengths extracted from spherical semi-variogram models ranged from 7.8 m to 25 m. Several semi-variograms indicated spatial autocorrelation distances greater than 25 m. These varying spatial structures and autocorrelation lengths suggest that the processes responsible for the formation of surface hoar vary between events at the same location and also vary depending on the location. These results may be influenced by the sampling scheme but do suggest conducting multiple weak layer investigations for slope evaluations in a meadow opening when surface hoar is present. These findings support prior research (e.g. Birkeland et al., 2010; Lutz and Birkeland, 2011) that suggest any investigations into buried surface hoar layers should incorporate multiple measurements and avoid closely spaced tests. Choosing the placement for these investigations should incorporate a basic understanding of a slope's shading and skyview characteristics, but with an understanding that stochastic and unknown influences may have produced irregular spatial patterns.

Findings for this study are unique to the examined meadows and may differ depending on weather patterns, slope aspect, or other site specific conditions. Careful snowpack examinations in meadow openings when a buried surface hoar layer is present should take into account the site canopy characteristics along with slope aspect. Seemingly uniform terrain may harbor large variations in surface hoar crystal sizes and point observations will likely not provide reliable information for the entire slope. ▲



Large surface hoar crystal found during data collection.

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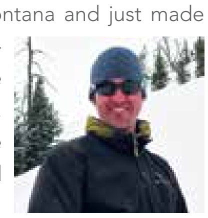
Matt was born and raised in Montana and just made the big move to Idaho after finishing his M.S. in Snow Science from Montana State University. He is currently forecasting at the Sawtooth Avalanche Center and loving the new terrain.



LEAVE YOUR THERMOMETER AT HOME…BUT DON'T FORGET YOUR LOUPE!

Recent AAA funded research shows that rather than capturing coarse resolution temperature profiles in your midwinter snowpit, your time may be better spent analyzing the snowpack stratigraphy and characterizing snow grain types found near suspected weak layers.

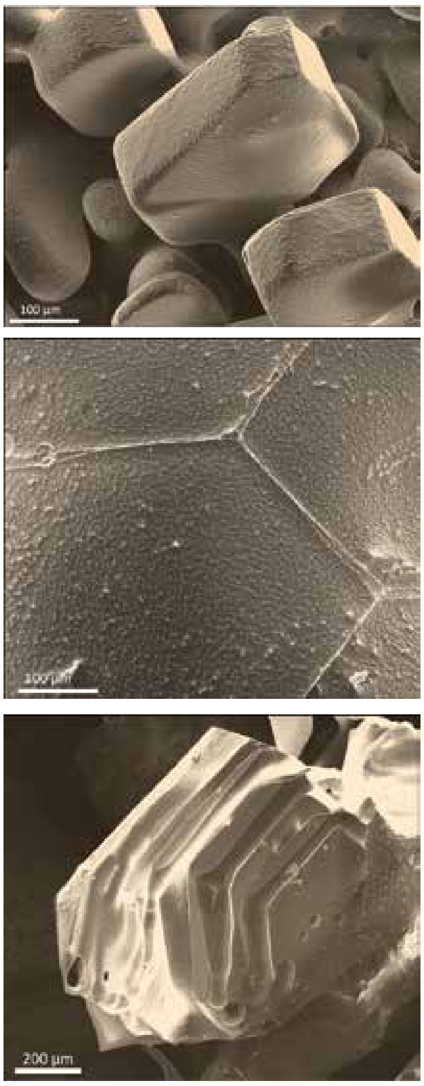
BY KEVIN HAMMONDS & ETHAN GREENE

As it turns out, spending many an extra cold and blustery minute trying to get those last few temperature readings from your snowpit wall for a textbook perfect "every-ten-centimeter" temperature profile may not be all that helpful, and if anything can even be misleading. Based on recent laboratory research conducted at the Dartmouth Ice Research Laboratory (see Hammonds et al. 2015) and succeeding other earlier but similar work (see Greene 2007), it would appear that perhaps the most critical of temperature gradients are those that cannot be directly measured…at least not with your standard field-based instrumentation.

In Hammonds et al. (2015), a study funded by the AAA, the authors created an artificial snowpack consisting of an ice lens sandwiched between two layers of old natural snow grains. They placed the sample under a controlled temperature gradient for 48-hours and observed the microstructural evolution of the ice-snow interface via micro-CT imaging while recording the temperature gradients within the sample with a custom built micro-thermocouple array. From the micro-CT imaging, new ice crystal growth occurred from the bottom surface of the ice lens while the top remained smooth. This observation was in line with the previous work of Greene (2007). In addition to Greene (2007), however, were the temperature gradients that were recorded near the ice-snow interface on a sub-millimeter scale. At these small scales, local temperature gradients were observed to be as much as 40 times that of the bulk temperature gradient that had been imposed over the sample. These results are thought to be of significance to avalanche forecasters for two primary reasons:

1) Slab avalanche activity has long been observed to occur near icy layers or crust/facet combinations in a region of the snowpack that did not necessarily have a measurable temperature gradient indicative of kinetic snow metamorphism. (Jamieson et al. 2001, Greene & Johnson 2002, and others)

2) Hammonds et al. (2015) showed that very large increases in the temperature gradient occur at very small scales in the snowpack around ice crusts. Such localized jumps in the temperature gradient on a sub-millimeter scale are not currently measurable with standard field instrumentation. Most temperature probes are themselves two millimeters in diameter and the typical resolution of a good dial-stem thermometer is +/- 0.5 °C.



Scanning electron microscope images show (a) ice crystal growth on the bottom surface of the ice lens, (b) smoothness of the top surface of the ice lens, and (c) kinetic snow metamorphism of an adjacent snow grain above the ice lens after 48 hours under a -100 °C/m temperature gradient. Figure adapted from Hammonds et al. 2015.

"What causes the jumps in the local temperature gradient near the ice-snow interface?" This occurs because such icy layers can act as thermal discontinuities to an otherwise thermodynamically homogeneous snowpack. Such results are not exactly intuitive…"isn't snow just made of ice?" The answer is "yes", but due to the crystalline structure and long range atomic order of solid ice versus the more disordered and loosely packed icy version of what we know as snow, thermal conductivities of ice compared to snow can differ by as much as a full order of magnitude (Petrenko & Whitworth 1999, Riche & Schneebeli 2013). This causes problems when individual snow grains come into contact with solid ice, as the pathway for conduction through the snow/ice matrix is compromised by the finite number of contact points that actually exist between the two, termed the thermal contact resistance. A function of the connectivity between the ice lens and the adjacent snow layers, the thermal contact resistance has been shown in a secondary study (Hammonds et al. 2016, in review) to be ultimately what is responsible for the marked increases in the sub-millimeter scale temperature gradients observed near the ice-snow interface. Although never before directly measured, many have suggested in the past (Colbeck 1991, Colbeck & Jamieson 2001, Greene 2007, and others) that such super-temperature gradients were likely to exist near an ice-snow interface and that enhancements in kinetic snow metamorphism could result. As a pertinent and memorable example of this scenario, large and widespread avalanche cycles associated with the Martin Luther King (MLK) rain crust in 2011 (see *TAR* 30.3) were more than likely the result of such enhancements in kinetic snow metamorphism occurring near the ice-snow interface. This MLK crust was observed to be a repeat offender as it would avalanche and then reload with a new snow slab. This is thought to have occurred because once formed, such ice lenses can only degenerate by the natural mechanisms of sublimation (slowest), destruction by an avalanche (fastest), or by becoming so significantly buried that compressional forces of the overlying snow slab aid in the bonding of the adjacent snow layers to the icy layer itself, thus limiting the effects of thermal contact resistance (most unsure and unsettling scenario).

So, to answer the question "Is it always worth getting a perfect every-ten-centimeter temperature profile in your snowpit?" The answer is quite simply "No." In fact, focusing too much on such large-scale temperature gradients can even be misleading as it may add bias to your opinion of what your observations of grain type actually mean. For instance, if you measure a bulk temperature gradient less than -10°C/m and identify a faceted crystal structure, it becomes very easy to assume the regime of "facets-going-to-rounds", when it may actually be the opposite that is occurring. Thus, based on physical evidence from recent laboratory testing (Hammonds et al 2015) that is in direct support of long-standing avalanche theory (Colbeck 1991, Colbeck & Jamieson 2001), it would seem most advantageous for us all to begin spending less time looking at our temperature plots and perhaps more time looking through the lenses of our loupe. ▲

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Ethan Greene is the current Director of the Colorado Avalanche Information Center (CAIC).

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IMPLEMENTING A NUMERICAL METHOD TO EXAMINE THE EFFECTS OF SNOW COVER DEPTH AND TEMPERATURE ON AVALANCHE RUNOUT DISTANCES AT BIRD HILL, SOUTH-CENTRAL ALASKA

BY KATREEN WIKSTROM JONES

Snow entrainment

Snow entrainment is the process when an avalanche erodes the snow cover in the avalanche path and intermixes the picked-up snow. Snow influx by entrainment is essential to counteract the development of shear gradients in the avalanche tail which consume mass from the bulk and gradually slows the avalanche down (Bartelt et al., 2007). The importance of snow entrainment has been well established (e.g. Gauer and Issler, 2004; Eglit and Demidov, 2005; Sovilla et al., 2007; Pudasaini and Hutter, 2007; Bartelt et al., 2012) and recent research efforts demonstrate the significant role the temperature of the entrained snow plays in determining the avalanche's mechanical properties (Vera Valero et al., 2015; Dreier et al., 2014; Steinkogler et al., 2014; Wikstroem Jones et al., 2014) and also how changes of the avalanche core temperature directly correlate to altered runout distances (Vera Valero et al., 2015; Naaim et al., 2013).

Bird Hill

At Bird Hill, between Anchorage and Girdwood in the Chugach Mountains, south-central Alaska, snow entrainment is believed to cause small release volumes (< 25,000 m3) to develop into unexpectedly large and long-running avalanches. Observations throughout the years indicate that avalanches that tend to go far at Bird Hill are either dry and cold, or warm and wet avalanches. The terrain of Bird Hill is steep and consistent with basically no transition zone, and with the Seward Highway and Alaska Railroad situated on a narrow strip of land between the terminus of the slope and the ocean. The snow climate at Bird Hill is typical maritime; precipitation often falls as rain at lower elevations and transitions into snow in the upper elevations.

Study design

Katreen's graduate research at Alaska Pacific University is a case study where she uses the terrain of Bird Hill to demonstrate the significant role the snow cover characteristics play for various avalanche flow behaviors due to the influx of mass and thermal energy through entrainment. The results are based on analyzing a large number of avalanches (n=236) that were simulated in the 2-D dynamical avalanche runout model called RAMMS in one of Bird Hill's avalanche paths. The project is the first application of RAMMS Extended Version in south-central Alaska and also the first use of RAMMS to investigate the effect of snow entrainment on runout distance under varying snow cover and release conditions. Besides its theoretical contribution, the project demonstrates the use of numerical avalanche models in avalanche runout distance assessments.

Before implementing RAMMS for avalanche simulations under an experimental design, Katreen calibrated the model by reconstructing six historical avalanches from Bird Hill. For those events she tuned certain model parameters in order to reconstruct the flows and runout distances. In the experimental phase, avalanches were simulated by changing a release or snow cover parameter one-at-a-time, meaning that the following simulation had either a release or snow cover depth changed or a release or snow cover temperature changed from the previous simulation.

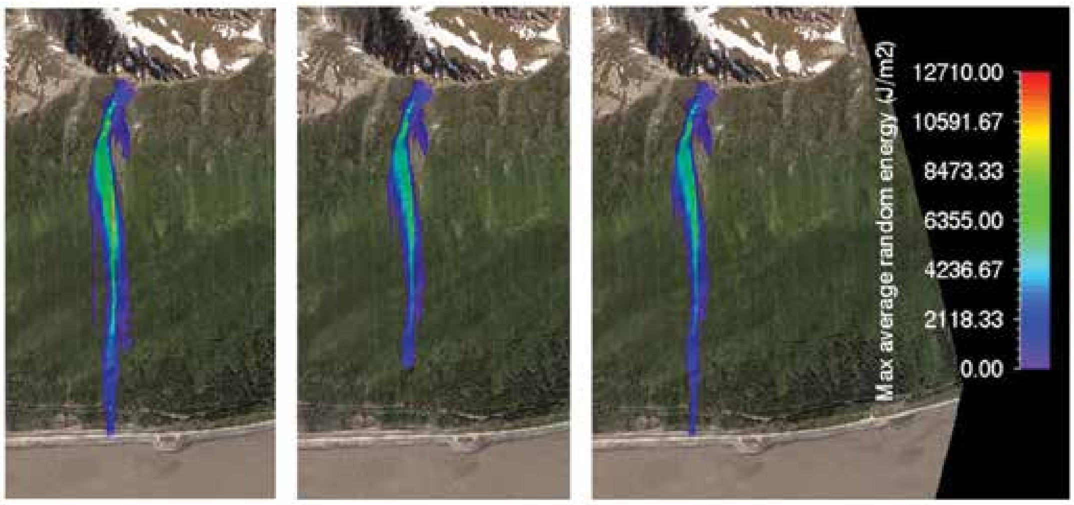

FIGURE 1: Maximum average random energy (J/m2) produced in avalanches of 1 m fracture depth and similar snowcover temperatures. (Left) Release temperature -5°C, snowcover temperature -5°C above 500 m a s l and -3°C below 500 m a s l. Maximum random energy produced was 12703 J/m2. (Center) Release temperature -3°C, snowcover temperature -3°C above 500 m a s l and -3°C below 500 m a s l. Maximum random energy produced was 9015 J/m2 (Right) Release temperature -3°C, snowcover temperature -3°C above 500 m a s l and -1°C below 500 m a s l. Maximum random energy produced was 9015 J/m2. No meltwater production was initiated in (Left) and (Center).

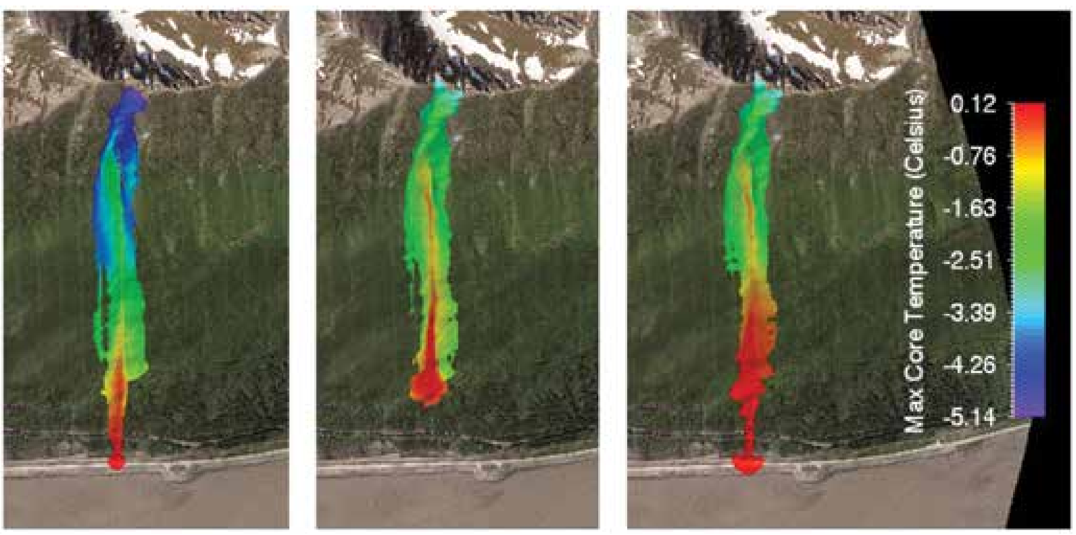

FIGURE 2: Decreasing effect of avalanche core temperature on runout distance. Release depth 1 m and consistent potential erosion depth of 1 m above and below 500 m a s l. (Left column) Release temperature -5°C, snowcover temperature -5°C above 500 m a s l and -3°C below 500 m a s l. (Center) Release temperature -3°C, snowcover temperature -3°C above 500 m a s l and -3°C below 500 m a s l. (Right) Release temperature -3°C, snowcover temperature -3°C above 500 m a s l and -1°C below 500 m a s l.

Avalanche flow regimes

In order to understand the link between avalanche temperature and long runout distances, we must consider the avalanche behavior under two general avalanche flow regimes: fluidization and lubrication. Fluidization describes the regime of when dry and cold snow granules are set in motion, and particle-particle collisions and collisions between granules and the bed surface create a dispersive pressure which causes expansion of the avalanche core, associated with high production rates of random kinetic energy (Buser and Bartelt, 2009). The increased space between the particles reduces the internal viscosity (Pudasaini and Hutter, 2007), generating fast-running avalanches and long runout distances (Issler and Gauer, 2008). Lubrication describes the regime of a wet avalanche with a laminar flow structure and meltwater concentrated at its base which reduces surface friction, leading to enhanced gliding and also long runout distance, here associated with high decay rates of random kinetic energy due to the molding of snow granules (Vera Valero et al., 2015). Avalanches that exhibit multiple flow regimes are common in maritime snow climates. Commonly the fluidized regime develops first with the cold released snow and transitions into a lubricated regime with entrainment of warm snow and dissipation of frictional heat energy at lower elevations (Wikstroem Jones et al., 2014).

Results: Snow conditions that cause drastic changes in avalanche flow behavior

Preliminary results of the experimental simulations show that the degree of influence the changes in snow cover depth and temperature had on runout distance depended on the initial release conditions. As expected, the larger release volumes (>35,206 m3) became far-reaching avalanches nearly independent of changes in snow cover conditions below the starting zone. The most interesting results were obtained for smaller releases (< 25,035 m3). Shown in Fig, 1-2: the longer duration of early developed fluidization (high production rates of random kinetic energy) from cold (-5°C) released snow compared to an early onset of lubrication (production of meltwater) caused by warmer (-3°) released snow, lead to dramatically longer runout distances. High-frictional "dampened" avalanches with short runout distances developed from -3°C snow due to lower production rates of random kinetic energy accompanied with lack of meltwater production *(Figures*

Field Obs

Helicopter avalanche control work resulting in a 13~15 foot crown measured by Peter "PJ" Moran.
Photo Grant Gunderson

1-2). During bare ground conditions below 500 m a s l, very early established meltwater production was a criteria in order for the avalanches to reach long runout distances.

In a comparison of snow cover depth effects, the results showed that small increases (0.25 m) in snow cover depths, especially in the upper elevations had a surprisingly insignificant effect (< 0.5% increase) on runout distance despite the on average large increase in total eroded volume (~50% increase).

Overall the results show that the effects of varying snow cover depth and temperature on avalanche flow behavior and ultimately the runout distance depended on:

- The avalanche characteristics at the time of entrainment which determine the interaction with the snow cover;
- How the entrained snow impact on the current flow regime, and
- What the terrain and snow cover look like below the zone of entrainment. ▲

Acknowledgment to AAA

The financial support from the AAA Theo Meiner Research Grant has covered helicopter flights during which Katreen took photos of avalanche events to re-construct in RAMMS and of terrain to produce her own high-resolution DEM by applying Structure-from-Motion photogrammetry. Before Katreen finishes her thesis this spring, she is going to re-simulate all scenarios using this high resolution DEM and also a new version of RAMMS. She hopes to present her final results at ISSW in Breckenridge in October.

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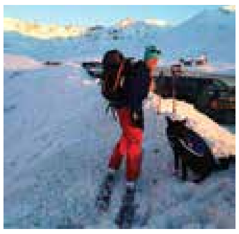
Originally from Sweden, Katreen moved to Alaska in 2010, where she enjoys skiing in the backcountry and learning about avalanche hazards and safety. She studied avalanche dynamics at Alaska Pacific University and just started her own avalanche consulting business directed towards the transportation and infrastructure industries, using RAMMS to analyze avalanche runout and assess mitigation strategies.



AMERICAN AVALANCHE ASSOCIATION

FUTURE AAA GRANT PROJECTS

PHOTOGRAMMETRY AT STEVENS PASS, WA

BY DAN VEENHUIZEN

With the extraordinary advances in "structure from motion" photogrammetry software and the capabilities of consumer level cameras, it is now relatively easy to produce highly detailed 3 dimensional models of complex surfaces at a cost that is a fraction of that of other methods such as LiDAR. Through a generous grant provided by the American Avalanche Association I am beginning a research project that utilizes this technology in a variety of ways.

At Stevens Pass Mountain Resort we face a number of avalanche problems including large planar slopes, potential expansion in avalanche terrain, and slide paths outside our boundaries that affect our in-bounds terrain. There are also several research questions we can address using photogrammetry (many of these have been identified by Dave Gauthier, et. al., in their paper, "Photogrammetry of Fracture Lines and Avalanche Terrain: Potential Applications to Research and Hazard Mitigation Projects." ISSW proceedings, Banff, 2014):

The hanging field on Rooster Comb at Stevens Pass
Photo Dan Veenhuizen

Objectives:

1. Avalanche Forecasting: We have several large slide paths that experience a wide range of snow distribution. Using photogrammetry to analyze the distribution of HS on these slopes would give us an advantage in implementing the correct control measures. See above as an example. One collection of avalanche paths, referred to as the Susan Jane ridgeline, is located outside of our ski area boundary but has runouts that affect our ski runs and the base of a lift. These paths are located in congressionally designated Wilderness and therefore certain parameters must be met before we can do explosives work on them. Using photogrammetry would be an excellent way to both make decisions about when mitigation is appropriate, as well as document all mitigation measures.

2. Avalanche Investigation: Our adjacent backcountry is heavily utilized and there have been multiple fatal avalanche incidents over the past several years. Using photogrammetry to document detailed investigations would be advantageous. We could define avalanche boundaries, crown heights, and debris volumes. A further advantage is that in a case of incoming poor weather/visibility, a set of photos taken the day of an incident could be analyzed in depth over time. We could also use these methods to investigate avalanches without human involvement, allowing us to build a profile of indicator slopes.

3. Hazard Mapping: As Stevens Pass expands its operational boundaries; photogrammetry would be a useful tool to help evaluate avalanche terrain. We could create 3 dimensional models that would allow us to estimate potential avalanche sizes, runout distances, and volumes that would aid in the placement of future lifts and ski runs. We could also begin to document avalanches in terrain now that we may expand into in the future.

Equipment and Methods:

There are many consumer-level cameras available that can take photos with high enough resolution to do this research. The other key component is that the camera must be GPS enabled. There are several different software packages that can accomplish my objectives. AgiSoft's PhotoScan Pro edition is a good option and was used by Gauthier.

The process of gathering data involves taking sets of photographs of the slope of interest. Taking several photos of the same slope with significant overlap lets the software create a 3D model by creating a dense point cloud. That point cloud can be compared to another set of photographs of the same slope after a weather or avalanche event.

Results:

Regarding reporting data from this project, at a minimum, one full season's worth of data should be gathered. Some of the objectives, such as trying to build a profile of new expansion terrain, would benefit from several years of data. Analyzing singular events, such as accidents and avalanche events, could of course be done as they happen. I see the process of sharing this information with the greater community happening in two stages: 1) A review and description of the information I can gather this season, and 2) A more in-depth analysis of all the research objectives after a few seasons.

I will present this information through a number of avenues such as: the ISSW, an article in *The Avalanche Review*, and/or presentation at our regional workshop, the Northwest Snow and Avalanche Workshop.

If anyone else out there is conducting research using photogrammetry I would love to hear from you! daniel.veenhuizen@stevenspass.com Have a great season. ▲

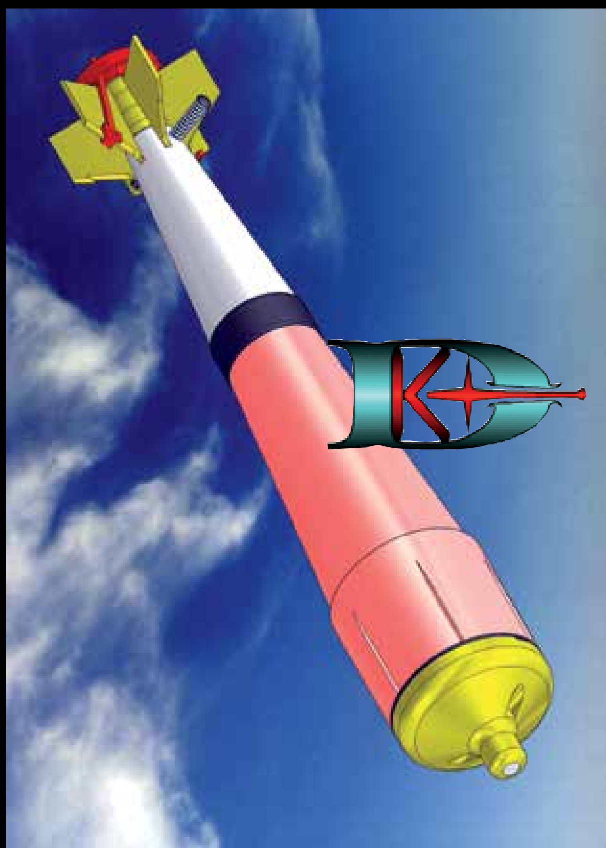
UPSIDE-DOWN STORMS AND HIGH AVALANCHE HAZARD IN THE NORTHERN SIERRA NEVADA

BY BENJAMIN J. HATCHETT

In maritime mountain ranges such as the northern Sierra Nevada Mountains of California and Nevada, the greatest avalanche hazard typically exists during and immediately following storms. Due to the nature of multiple landfalling midlatitude cyclones or wave trains in this region, it is not uncommon for upside-down snowpack structures to develop when a warmer storm follows a colder storm. When this occurs, more dense snow overlies less dense snow and a slab/weak layer combination is created, leading to instabilities in the storm snow and contributing to avalanches. Here we hypothesize the following: 1) that upside-down storm events are associated with the majority of high avalanche hazard days in the northern Sierra Nevada, 2) copious moisture transport by atmospheric rivers will contribute to significant snowpack loading during these events, and 3) that synoptic and mesoscale frontogenesis and deep convection will create the observed varying temperature regimes and strong vertical motions causing rapid precipitation rates and varying snow densities that promote storm snow instabilities.

To evaluate these hypotheses, we are using a combination of avalanche hazard forecasts, avalanche and snowpack observations archived by the Sierra Avalanche Center, surface station data from 26 SNOTEL stations, and an S-band radar to estimate snow level during 2007-2015. The atmospheric conditions that lead up to and occur during the upside down storm events are assessed at the planetary, synoptic, and mesoscales using gridded 32 km horizontal resolution North American Regional Reanalysis and 2.5° horizontal resolution NCEP/NCAR Reanalysis products. To identify atmospheric rivers and evaluate the vertical structure of the atmosphere, we use the Scanning Satellite Microwave Instrument (SSM/I) and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) platforms in conjunction with the reanalysis products. Beyond providing important insight into how upside down events are produced and how they can be forecasted, we hope to highlight available data sources, such as SSM/I and CALIPSO, which can be used in other avalanche case studies.

In a recent (October, 2015) *TAR* letter to the editor, Doug Krause brought up the fact that peer-reviewed research can be difficult to access for those without a university association. The 2015 AAA Graduate Research Award will cover the open-access publication fees and enable our findings to be published in a journal that is readily and immediately accessible to the avalanche community, details unavailable at press time. ▲



▲ The DeltaLancer System.
Under License from Kevin Powell at
Delta K Explosive Engineering Systems Ltd.

▲ The New Redesigned
CIL Classic Snowlauncher.

Photo: Freya Fennwood Photography | Leif Whitaker and crew on East Kariba peak in Shimamaki, Hokkaido, Japan.

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