THE Avalanche REVIEW

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Playing BATTLESHIP

Doing battle with buried surface hoar calls for some innovations in strategy; here are some ideas to get us started.

Story by Scott Davis

This SS-N-R2-D2-O avalanche (photographed via helicopter on April 2) failed on buried surface hoar approximately 1m deep, which formed between March 20 and 22 in the Chilkat Range near Haines, Alaska.

Photo by Matt Borish

See more on tracking this layer from Matt Borish on page 16

I am not sure who remembers that childhood game called "Battleship." It's a game where you call out letter/number combinations, hoping they correspond with a square on your opponent's grid that contains one of their battleships – basically a hit-or-miss kind of thing. I am reminded of this game every time I trounce around in terrain with a buried surface hoar layer that I never observed while it stood proud in the light of day.

You know it always seemed it would be easier to win at Battleship if you could somehow get a peek at your opponent's layout before you started, but of course that would be cheating! I suggest the same is true for us "avalanche poodles." Remember, this is a game we all want to win, even if we cheat a little bit.

Canadian avalanche professionals are pretty good at recording to standards and disseminating endless streams of information and data, and we should congratulate ourselves for that. But we also need to acknowledge how lame we are at tracking and mapping surface hoar in a meaningful and useful way.

Currently, to the best of my knowledge, this is the state of affairs. Observations of surface hoar formation are noted in personal field books, perhaps commented on in the InfoEx

See story continued on page 17 ➡

In *Playing Battleship*, Scott Davis issued an open-ended challenge to the avalanche community on tracking weak layers. That article first appeared in avalanche.ca and – at the suggestion of a TAR subscriber and with CAC permission – we're reprinting it here. Alongside it we're publishing responses to a variant of Scott's challenge that I sent to a wide variety of snow aficionados:

How do YOU map/track the distribution of a weak layer? Show me a page from your pit book, an overlay that is electronic or hand-drawn, a coherent narrative that is easy to interpret. Industry standard or personal innovation? What do you use/what are your considerations?

From the variety of responses, it's clear not everyone plays Battleship the same way. You may not agree with all the viewpoints or need the sophistication of some of the tools, but I hear a similar message in each: "Pay attention!" *—Lynne Wolfe*

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I talk snow with everyone I run into and then digest what they say about the weak layers. This motivates me to dig even more, because a lot of what you hear doesn't make any sense, but it helps me to look for layers I might have missed.

—Kent McBride, *Playing Battleship*, page 19

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The mission of the AAA is:

A. To provide information about snow and avalanches;

B. To represent the professional interests of the United States avalanche community;

C. To contribute toward high standards of professional competence and ethics for persons engaged in avalanche activities;

D. To exchange technical information and maintain communications among persons engaged in avalanche activities;

E. To provide direction for, promote, and support avalanche education in the US;

F. To promote research and development in avalanche safety.

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from the executive director

Another Fantastic ISSW Enjoyed by Many Colleagues

Our executive director stopped at a hot spring in the middle of Nevada on his way home from ISSW. *Photo by Sandy Kobrock*

ISSW is always a good way to start the winter and the timing was excellent this year. We had a fantastic week with an amazing Sierra field day, left with snow falling at Squaw, and most of us returned to snow in our home mountains. And people are already getting caught in avalanches in Colorado. Oh my…

Thanks to Russ Johnson, Lel Tone, Mike Ferrari, Gary Murphy, and the rest of the ISSW 2010 crew for putting on another fantastic gathering of the avalanche tribe. The setting was spectacular and was matched by the program, entertainment, and attendance. Having served my avalanche apprenticeship in Squaw Valley, it was a great homecoming for me. I connected with many old friends (both in and out of the snow game) and met some of the Squaw Valley ski patrol's new avalanche hunters. Looking out my hotel window every morning was inspiring. I had forgotten how beautiful the valley is.

We are ushering in some new board members who will take office January 1: Dale Atkins as president, John Stimberis as vice president, Mike Ferrari as treasurer, Brett Kobernik will take on our Web and IT needs, and Krister Kristensen will take over as European section representative. I look forward to working with you. Thanks to outgoing board members: Doug Richmond, Bill Glude, Peter Höller, and Janet Kellam. Many thanks to all and thanks to those who continue to sit on the board and guide our organization. Their enthusiasm and positive energy make AAA an extraordinary organization to be a part of.

I am not sure I can adequately put into words my admiration for the job Janet did as our president during the last four years. She saw what needed to get done on several fronts and kept us on course. She was instrumental in fitting all the parts together that have become the new avalanche.org. The amount of time she spent on these and other tasks was monumental, and she still found time to help me when I needed an ear or a shoulder. Thanks Janet.

We had our largest crew of new members for approval by the governing board at the fall meeting. New member applications continue to arrive and winter hasn't even really started. Your membership dues remain the main source of our operating funds and an increasing membership will allow us to add more value to AAA membership. Encourage membership among your colleagues and co-workers. Memberships are only accepted online now and information can be found on the AAA Web site.

Thanks to everyone who came by the AAA booth to say hi or conduct a little business. It's great to be able to put a face to the name in the database. At our annual meeting Dale Atkins, our incoming president, spoke of AAA standing for, "community, friendship, and professionalism." That sounds like something I really want to be a part of. I wish you all a safe and successful winter. Take care of each other out there. *—Mark Mueller, AAA executive director*

from the editor


At the Avalanche Divas event *(see story on page 6)*, Janet Kellam and Lynne Wolfe share a bottle of wine that Sue Ferguson had bottled to commemorate the 20th anniversary of *The Avalanche Review*. Sue would have been proud to share a bottle with this year's Divas. *Photo by Lel Tone*

Snow Community Connected

Home from ISSW and putting the final touches on TAR 29-2, my editorial topic leaps out at me: I am continually surprised and pleased by the power of community and how lovely it was to see so many of you face-to-face. Our snow and avalanche community is full of energy, questions, commentary, and suggestions. We have a powerful thirst for information, for better ways to do things, and for free beer. (How many kegs did we go through at Squaw happy hours, Kevin?) As a community we are better connected than ever before. This is evident in ISSW research presentations where scientists exchanged ideas and techniques instantaneously, in the viral nature of dramatic accidents like Saddle Peak or Iron Mountain, and in my work gathering material for *The Avalanche Review*.

We have initiated a number of email correspondence projects over the years; spatial variability back in 2004 and resetting the snowpack earlier in 2010, for example. This issue contains yet another – the Battleship project – where we explore the variety of ways that backcountry travelers, professional to serious recreationists, track and map weak layers *(see this set of stories beginning on the cover and continuing to page 16)*.

Through the power of electronic immediacy I become better able to accost more and more of you with the questions we are working on and wrestling with. There's no substitute for being out in the field with your mentors, peers, and friends, but at least we can quickly share our problems and solutions. In this issue of TAR we read about Dan (Howie) Howlett and Dan Judd receiving the AAA's honorary membership award *(see next page)*; now we are truly benefitting from their vision in moving the avalanche world to what we now know was the inevitable electronic future.

Also in this issue you'll find three views of La Niña from TAR stalwarts Rich Marriott, Mark Moore, and Jim Woodmencey *(see page 14)*. You'll both "get it" and get a laugh from our resident comedian meteorologists. Public thanks to all of you for agreeing to write for TAR – and not just for this edition.

Rounding out this issue are a few more season summaries from last winter *(see page 25)*, stunning expedition logs from Hans Saari grant recipients *(see page 28)*, case studies from earthquake-triggered avalanches in New Zealand *(see page 22)*, plus more rescue updates.

We'd like to offer the service of having *The Avalanche Review* sent as a low-resolution pdf attached to an email for our European subscribers. This would initially be in addition to the print subscription, but we are still working out the details. Please contact me or Mark Mueller if you are interested in this option or have an opinion (even if you don't live in Europe). Don't worry, we'll never go completely digital on you – you'll get a hard copy for your patrol shack or throne as long as I'm editor.

In other avalanche news, the AAA snowmobile-education project is chugging along. Our working group met at ISSW and got closer to finalizing avalanche-course guidelines. You'll see those as well as many perspectives on working with sledders in TAR 29-3. Contact me ASAP if you'd like to be involved.

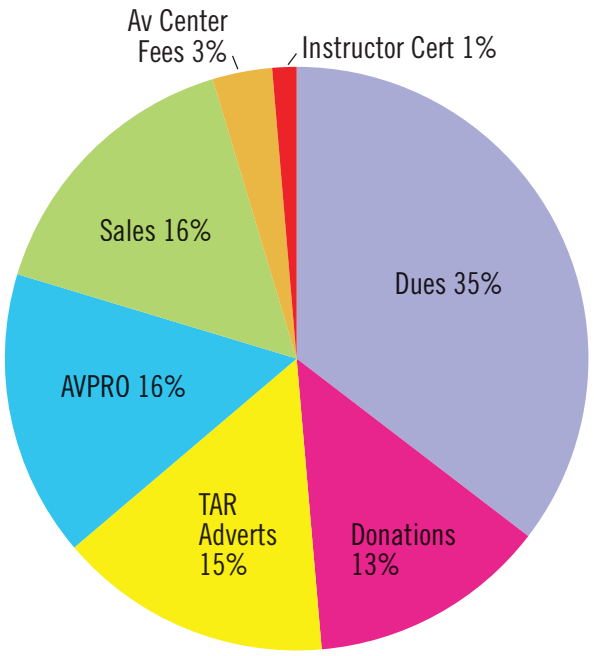
TAR 29-3 will also include articles around two other themes: fracture mechanics and some of the new research; post-control releases – experiences and lessons, plus perspectives on ISSW from the practitioner (Doug Richmond) and the scientist (Andy Gleason). Deadline is December 15 for those submissions.

TAR 29-4 is loosely organized around the human factor, decision-making, and case studies that especially showcase mistakes/lessons by professionals and experienced backcountry travelers. Deadline for that material is February 15.

—Lynne Wolfe

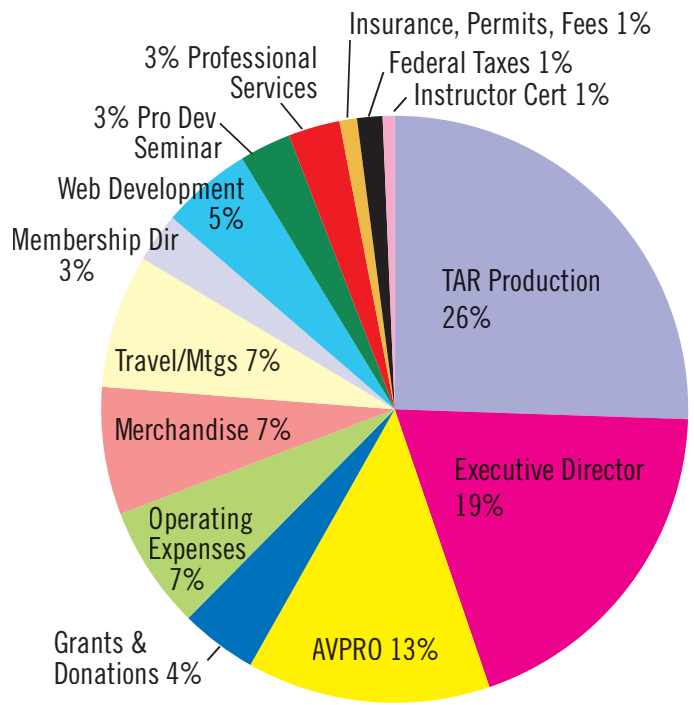
aaa news

AAA INCOME • WINTER 2009/10



ITEM	INCOME	%
Dues	$36,929	36
Donations	13,791	13
TAR Advertising	15,818	15
AVPRO	16,560	16
Sales	16,353	16
Avalanche Center Fees	3,450	3
Instructor Certification	1,400	1
TOTAL	$104,301	

AAA EXPENSES • WINTER 2009/10



ITEM	INCOME	%
TAR Production	$27,162	26
Executive Director	20,450	19
AVPRO	14,264	13
Grants & Donations	4,497	4
Operating Expenses	7,229	7
Merchandise	7,469	7
Travel/Meetings	7,827	7
Membership Directory	2,911	3
Web Development	5,290	5
Pro Dev Seminar	3,025	5
Professional Services	3,021	3
Insurance, Permits, Fees	1,026	<1
Federal Taxes	1,486	<1
Instructor Certification	700	<1
TOTAL	$106,357	

Daniel Howlett and Dan Judd Awarded Honorary Memberships

Story by Halsted Morris

Honorary membership is the highest award bestowed by the AAA. It is given to persons who have distinguished themselves by special achievement in the field of avalanches. Most of the 2010 AAA general membership meeting at Squaw Valley ISSW in October was taken up with the AAA awards ceremony. A future article will highlight the other award recipients, but this article features Daniel "Howie" Howlett and Dan Judd, because their awards were approved in spring 2009.

AAA president Janet Kellam commented before reading the awards citation, "With the advent of the Internet, new technology and communications had a potential to splinter the avalanche community. Dan and Howie, by implementing avalanche.org and engaging in it, did just the opposite." Below is the citation for Dan and Howie.

American Avalanche Association
Honorary Membership Citation
Daniel "Howie" Howlett and Dan Judd

The American Avalanche Association is proud to present its highest award – Honorary Membership – to Daniel "Howie" Howlett and Dan Judd. There is no way to write individual citations for these two gentlemen, because their partnership is so close that only a single citation can do justice to their achievements.

To paraphrase Mark Moore's presentation about the onset of the information age, before the arrival of the Internet the American avalanche community was without form. Our community gathered and communicated at biennial ISSWs or through *The Avalanche Review*. Only via the infamous "green

Continued on next page ➡

AAA AWARDS

continued from previous page

and blue sheets," *Powder Cloud Times,* and fledgling Westwide Network did the American avalanche community begin to learn what was happening in other regions. Leadership was needed to bring communication and information sharing within the American avalanche community in line with current technology age.

Dan Judd was working as a UDOT avalanche forecaster whose main focus was to bring Little Cottonwood Canyon into the electronic age. Dan was the right man with the computer skills and knowledge to help. His TAR column – *Nuts and Volts* – introduced the newest technologies to field predicators in a meaningful way. Suddenly, avalanche workers started to see the benefits of ultrasonic snow-depth sensors, Snowlink, graphical snowpit programs, data-logger data management, Snotel, and how to manage automated weather stations. Even today rereading many of these columns is enlightening and shows just how far we have come. Dan's columns were a gelände jump into the high-tech age, creating the basis for what would become "Dan and Howie."

Daniel "Howie" Howlett was, and remains first and foremost, an Alta ski patroller, but one with a penchant for mechanical stuff and technology. There are few people in any given industry who are known by a single name, and Howie has become known worldwide by that moniker. Howie has joined the ranks of Pelé, Lance, Madonna, and Cher – at least as far as the worldwide snow community goes.

As a teenager in the 1970s, Howie hung-out around the Alta ski area. Ski patrol director Doug Christianson hired Howie on to the Alta ski patrol. To this day no one seems to be sure if Howie was even old enough to be on the patrol when he was hired. Howie's parents have never forgiven Stuart Thompson for the part he played in Howie's ski patrolling career, because he spent more time skiing than hitting the books.

Lacking willing volunteers to run the Avalauncher program at Alta, Howie stepped up to the job and developed a program parallel to the artillery program. Thus began Howie's entry into the snow-safety profession. This would lead to Howie falling under the technological influences of Dan, and eventually forming their working partnership.

Avalanche.org was their grandiose vision; it was to unite the community, and they identified that vision long before the rest of the avalanche community knew about the Internet. Avalanche.org began as an altered rebirth of the Westwide Avalanche Network, but also meant to provide a public focus on the avalanche profession, and it included an information exchange – concepts borrowed from the CAA.

A number of assistants helped prod the concept along, but it was Dan and Howie who spent countless hours with tech manuals on their laps as they coded late into the nights to launch the first true North American avalanche-oriented Web site. They maintained and upgraded the site through the years of advancing technology, service providers, broken links, and Bulgarian hackers, helping avalanche.org to become the flagship Web presence it is today. As Howie mentioned in early years of avalanche.org, most of his co-workers at Alta thought "Netscape Navigator" was a new automobile to replace the "Gremlin."

Howie (left) and Dan Judd look on as Janet Kellam reads their citation for the Honorary Membership award. *Photo by Halsted Morris*

Perhaps Bruce Tremper summed it up best: "I think that we are all grateful for all of the dedication and effort put into the old Westwide Avalanche Network (now avalanche.org), when the primary tenets for them in this expanding computer era were, 'Will program for food.' Their efforts in developing this avalanche resource or clearinghouse for avalanche forecast and control operations have made all of our regional or local centers that much more accessible and available by interested users, and has fostered increased communication and information sharing amongst us all.

"It's truly amazing how much beyond 'commonly accepted responsibility' their efforts extended in keeping avalanche.org alive and well…even to Dan hauling servers between physical locations and getting the site back up and operational during some nasty winter storms; while also their devotion to excellence has extended into other activities well beyond avalanche.org, such as with their more income-producing work.

"In short, the Judd snow-depth sensor has become a standard in much of the avalanche industry and is now an integral part of many major governmental weather systems due to its reliability and relatively low cost. We would have a hard time doing what we do without the robust information provided by such sensors. Meanwhile, the NoHow instrumentation expertise of Howie – as well as a host of programming issues with a variety of data loggers and communication systems – have made some instrumentation sites possible and made all of our instrumentation data more functional and easy to use. Many of us have taken the leap into new and uncharted communication or instrumentation waters because of Howie's or Dan's recommendations, although at times these waters swirled well over our collective heads with only occasional gasps for air. Nevertheless, they have helped to lead us into a better place, for the avalanche industry, for the mountain weather folks, and for the public that rely on such data and forecasts."

Their contribution to the avalanche community has no precedent, and it is hard to imagine how it can ever be equaled. There are few individuals who the avalanche community owes so much to as Howie and Dan.

As defined in the AAA awards criteria, Daniel Howlett and Dan Judd have distinguished themselves through outstanding career achievement in the field of snow avalanches and are therefore qualified for Honorary Membership.

Halsted Morris currently serves as AAA Awards and Memorial Chair. The rest of the awards will appear in TAR 29-3.

metamorphism

Congratulations to our new AAA members, voted upon at the fall board meeting:

New Pro Members
Njord Rota - Glenwood Springs, CO
David Reichel - South Lake Tahoe, CA
Rich Meyer - Berkeley, CA
Garan Mangan-Dimuzio - Telluride, CO
Clark Corey - Stanley, ID
David Dellamora - Dillon, CO
Johnny MacKinnon - Crested Butte, CO
Sean McManamy - Hope, AK
Winthrop C. Allen - Santa Fe, NM
Paige Pagnucco - Logan, UT
Daniel Miller - Bozeman, MT
Jeff Lane - Center Conway, NH
Matt Primomo - Denver, CO
Mick Riffie - Cascade, ID
Eric Knoff - Belgrade, MT
David Cooks - Bend, OR
Seth Koch - Gustavus, AK
Tom Thorn - Big Sky, MT
Nick Hall - Leavenworth, WA
Leighan Falley - Talkeetna, AK
Nathan Garfield - Snowmass, CO
Peter York - Truckee, CA

New Member Affiliates
Julian Pridmore-Brown - La Grande, OR
Mark Renson - Hudson, MA
Nick Pope - Portland, OR
Les Blomberg - Montpelier, VT
Eric Lieberman - Truckee, CA
John Boburchuk - Windber, PA
Ming Poon - Tahoe City, CA
Brian Napier - Denali Park, AK
Chris Bremer - Ogden, UT
Ella Darham - Bozeman, MT
Gary Falk - Wilson, WY
Nick Lyle - Freeland, WA
Casey Bristow - Pagosa Springs, CO

A few thoughts from Fay Johnson about Doug Richmond, who is simultaneously retiring from his long-held position on the AAA board as vice president and stepping up to fill Fay Johnson's shoes as ski patrol director at Bridger Bowl:

Doug Richmond comes down out of the cold east wind one day in January 2008. *Photo by Fay Johnson*

Doug Richmond started patrolling at Bridger in 1977.
• He left Bridger in 1988, but returned in 1993.
• He became Assistant Patrol Director and Snow Safety Director at Bridger in 1996
• He turned over the Snow Safety position in 2008, but remained the Assist. PD
• He became Patrol Director in 2010

Favorite sayings:
"Get out there and make me look good."
"I told those guys to do that."
"We can't all come back alive."
"Put it on my tombstone…I was too chicken to open the Ridge."
"Be ready when the baloney sandwich hits the fan."
"I represent the peanut butter and jelly crowd."
"Say it once, and keep it brief."

Richmond is affectionately known as "Joe Schmo," "Big Joe," or "Joe Doug." He has always been very involved in avalanche education and public awareness in southwest Montana through MSU and Bridger Bowl. He has also being an active and contributing member of AAA for years.

above: Fay Johnson giving us the mitten after 14 years as fearless leader. *Photo by Ella Darham*

right: Fay with Olive. *Photo by Doug Richmond*

And a few thoughts from Doug Richmond regarding Fay Johnson, who just retired as patrol director at Bridger Bowl:

Fay Johnson was a grad student at MSU during the early '80s.
• During ISSW '82- [some sort of title] Detail Director – made Doc Montagne look good – she set the mission, "a merging of theory and practice,"
• She patrolled at Bridger for 27 years, starting in 1983.
• She was assistant ski patrol director for five years: 1991-96,
• She was patrol director for 14 years: 1996-2010. Best there's ever been.

Fourteen years of greatness; Fay led the Bridger Bowl ski patrol with even-keeled competence, humor, and grace. She demanded excellence. She developed a culture of training and made it fun. But enough of that. She says she will show up for work now and then this winter, so maybe we'll get her back. We are keeping her office for her. You'll only go in there if it's about money, or you're in trouble.

Bill Glude on Sheep Mountain above Juneau in June of 2006. *Photo by Mike Bartholow*

After 10 years of service, **Bill Glude** is stepping down as a member of the American Avalanche Association's board of directors. Based in Juneau, Alaska, Bill was the founder and director of the Southeast Alaska Avalanche Center. A long-time educator at University of Alaska Southeast and the Alaska Avalanche School, Bill has mentored countless students through beginning and advanced avalanche courses. His work as a forecaster, guide, and industry consultant has brought him all over the world on his skis and snowboard. We'd like to thank him for his enthusiasm and hard work for AAA over the years.

what's new

Avalanche Divas Night, ISSW 2010

Story by Aleph Johnston-Bloom, Lel Tone, Kim Grant, Solveig Gerhardt

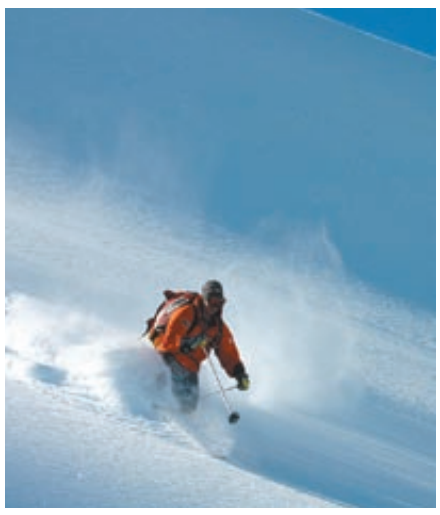
The third biennial Avalanche Divas Night was held as part of the International Snow Science Workshop in Squaw Valley on October 18. The event was an incredible success with more than 100 female attendees from all over the world gathered to celebrate the contributions of women in the snow and avalanche industry.

The event offers female ISSW attendees the opportunity to gather, share information, and network with other professional women in the industry and honors women who have made significant contributions to the field of snow and avalanches. The Divas organization aims to provide mentorship opportunities, to preserve the history of women's contributions to this field, and to create a support network and legacy of women in the industry. Additionally, the Avalanche Divas scholarship fund empowers women to cross new boundaries in the field of snow and avalanches.

During this ISSW, almost $6000 was raised, along with an extraordinary amount of donations in product. Most of the money covered event costs, and $1500 went into a scholarship fund for continuing education, travel expenses to future ISSWs, and costs for the next Diva Night at ISSW 2012 in Anchorage.

Between ISSWs, a Facebook page has been established as a means for women to network: search term *Avalanche Diva's* [sic].

During the 2010 ISSW, five women were honored for their contributions to our industry: Patty Morrison, Sylvia Forest, Jos Lang, Lori Zacaruk, and Paola Dellavedava. They were presented to the entire ISSW community – 900 people representing more than 20 countries – at the banquet. A special toast was made in honor of the late Sue Ferguson, founding mother of the American Avalanche Association and *The Avalanche Review,* with a bottle of red wine that she had bottled with *The Avalanche Review* label.

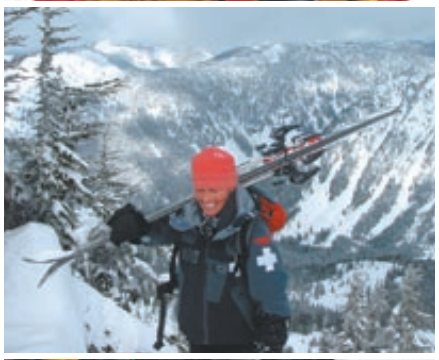


Jos Lang: Canada

Jos is assistant operations manager at Last Frontier Heliskiing. Born in New Zealand, Jos graduated from the University of Otago in chemistry and climbing; she probably put an equal number of hours into both! After a sojourn in South America she arrived in Whistler to learn to ski. She subsequently began ski patrolling and graduated to avalanche control. Jos became a full UIAGM guide in 1981. She guided with CMH for 15 years, mostly in the Bugaboos, before moving to Last Frontier, where she has been for the last 10 years.

Sylvia Forest: Canada

Sylvia knows Canada's backcountry as well as most people know their own backyard. She has been exploring remote regions since childhood, and today she is one of the country's leading female mountain guides and a public safety coordinator and rescue specialist at Mount Revelstoke and Glacier National Parks in British Columbia.



Patty Morrison: US

Stevens Pass Professional Patrol, Stevens Pass Avalanche Forecaster, Certified AIARE Level I Instructor. Patty has been a professional patroller since 1989 and has a passion for teaching and sharing her knowledge of snow, weather, and the excitement of the mountains. She is also the Northwest section rep to the AAA board.

Lori Zacaruk: Canada

Lori is a leader in the field of snowmobile avalanche awareness and education. Talk about crossing boundaries; she has taken the machine by the handlebars and held on for a wild ride. She has taught thousands of snowmobilers avalanche skills, leading the way for further education development and outreach. She tirelessly attends meetings, participates in discussions, and campaigns for improved avalanche education for snowmobilers.

Paola Dellavedava: Italy

From AINEVA in the Valle d'Aosta, Paola has contributed much in the establishment of the relatively young avalanche-forecasting program in the Aosta region in northern Italy. She is also a member of the European Working Group of the Avalanche Forecasting Services, where she contributes to the harmonization and optimization of European forecasting products.

A special award was presented to *Doris Hendrickson* by her husband Dave. The following is excerpted from his presentation:

I come before you today to ask for your consideration of honoring my wife for her accomplishments in the nearly six decades of support and help she has provided me in my long and busy life of ski patrol, Forest Service, and other federal and state service in the state of Alaska. Even though she seldom accompanied me in my daily and/or weekly ski patrol/work activities, first as a volunteer and later as a professional, she was the one person who accomplished all the truly tough tasks: scheduling patroller duty days, setting up meetings for avalanche courses, doing administrative paperwork to submit to the National Office, and a myriad of other requests – along with raising our family of seven daughters and making sure I was fed and clothed in first my military, then government careers throughout the years. She steadfastly supported me and NSP in the formative years of Alyeska ski resort (1959-1963) and beyond from 1964-1982 while I was the divisional avalanche supervisor/advisor for NSP Alaska Division – proofreading class papers, coordinating schedules – the list goes on and on.

In our most recent endeavors (the last two decades), as a team we have been grooming trails and providing consultation services to the Alaska State Parks rangers at Hatcher Pass Management Area, handling 50+ miles of snowmachine, multi-use, and Nordic ski trails. My wife keeps track of where I am working and making sure I remember to carry my beacon and rescue pack in the Snocab, as well as completing an outgoing radio check: "Did you turn your beacon on?" Then she watches the weather and, of course, worries if I am a little slower than normal returning from the six-hour run over the west side of the turnaround. I am required to contact her as soon as I reach the summit west of Hatcher Pass Lodge so she knows I am okay. ❄

2010 Diva honorees (l-r): Jos Lang, Doris Hendrickson, Patty Morrison, Patty's friend Emily, Lori Zacaruk, Paola Dellavedova, Sylvia Forest.

2010 Diva Night organizers (l-r): Lel Tone, Solveig Gerhardt, Aleph Johnston-Bloom, Kim Grant.

Ninth Annual Colorado Snow And Avalanche Workshop Held in October

Story by Scott Toepfer

The ninth annual Colorado Snow and Avalanche Workshop (CSAW) brought over 330 people to Leadville, Colorado, on October 8. The Colorado Avalanche Information Center (CAIC) has been the main organizer of all nine CSAWs, but this year the American Avalanche Association, Summit Foundation, and the Friends of the CAIC joined forces to maintain a high-quality and low-cost day of continuing educational for avalanche professionals.

This year's event started with a bang as Brian Ciciora discussed the Backcountry Access (BCA) airbag system. Ciciora explained the concepts behind airbag avalanche safety systems and the development of BCA's Float30. Next up was Peter Carvelli from the Aspen Highlands ski patrol. Carvelli gave a talk on random shot-placement techniques and how to master that tricky protocol during the course of a long winter. The presentation closed with some very good take-home points that were well worth the price of admission.

Next were two talks on avalanche rescues from last season. The first occurred on Tenmile Peak in Summit County, Colorado, on May 1. This mission required some tough choices on the part of the rescue team and the two helicopter crews involved. Dan Burnett and Aaron Parmet of Summit County Search and Rescue discussed the decisions that were made in keeping both the ground crews and the patient safe from further harm. Then, one of the biggest hits of the day was Brad White's take on the Boulder Mountain avalanche in British Columbia, Canada, last winter. After seeing the carnage and the potential for absolute chaos at the scene of this large, multiple-burial avalanche, all the participants at CSAW 2010 were blown away by the fact that only two people were killed during an event that buried up to 60 people.

Leading into the lunch break, Doug Krause with Silverton Mountain presented a discussion of communication and its role in daily avalanche work. For many people this topic may seem a review, but we all know communication plays an all important role in snow safety, control teams, and how we get the job done right. Most avalanche workers are not known for being extraordinarily verbose in our daily lives, but the part our ability to communicate plays in our work can be of life-and-death importance. Krause did a great job in getting that across to the audience.

Probably the toughest time slot for speakers comes right after lunch. Ben Pritchett gave a short presentation on a new program the CAIC is building to address accidents in the Colorado sidecountry. This program has great potential and needs the support of local avalanche-safety operations. Of course, an annual highlight of the event is Joe Ramey with the National Weather Service and his winter weather outlook. With La Niña wandering around the tropical Pacific Ocean, there are some fairly certain signs of what the winter will produce – but unfortunately not so much for Colorado. However, Joe once again stuck his neck out by predicting what our winter in Colorado will most likely have in store. Once again, dust on snow is almost certain to again plague our snowpack.

This topic led nicely into Chris Landry's (Center for Snow and Avalanche Studies) presentation on dust-on-snow events and the effect of these events on avalanche conditions. No one in the audience could find a positive side to the now yearly phenomena, but it is something we are going to have to learn to live with into the foreseeable future.

Tara Chesley-Preston, from Montana State University Department of Earth Sciences, flew down from Bozeman to discuss her findings on spatial patterns of natural avalanching associated with upper-air wind direction in the mountains surrounding Gothic, Colorado. billy barr, past caretaker at the Rocky Mountain Biological Laboratories in Gothic, Colorado, kept impeccable records of daily weather and avalanches for over 30 years. It is one of the cleanest weather records in Colorado, and Chesley-Preston displayed her research correlating upper-air winds and avalanche activity. All mountain locations are dismally short on wind and weather data, and this work could help forecasters in looking at free-air data to determine avalanche possibilities across small mountain ranges.

As Backcountry Access staff set up the after-event social hour, Mark Beardsly with the Breckenridge ski patrol took a look at a large and winter-persistent, near-surface facet event that brought on a few large (and some surprise) avalanches during the entire winter of 2009/10. Finally, Ethan Greene gave a quick talk on the new North American Public Avalanche Danger Scale that we will all be working with this winter.

Many thanks to the CAIC staff for helping organize and run the event; to our three major sponsors (AAA, the Summit Foundation, and the Friends of the CAIC); and to the commercial exhibitors (Recco, Orica USA Inc., CIL/Orion, Ortovox, Mammut, Backcountry Access, and Brooks-Range Mountaineering). Lastly thank you to all of the speakers who took time to develop and present talks that will help avalanche field practitioners.

Scott Toepfer is a forecaster with the CAIC.

Pic 2G IMSI Catcher Device May Revolutionize Search and Rescue

Story by David George

A system being developed by the French company Diginext could revolutionize the search for people lost in mountains – even those buried under an avalanche – by utilizing cell phone signals to find and communicate with victims.

The Pic 2G is a portable IMSI (International Mobile Subscriber Identity) catcher designed to act as a base station for any cell phone within range. About the size of a portable computer, the device connects to a directional antenna, and an operator sees both a direction and distance readout enabling a mobile phone to be localized similar to an avalanche beacon.

During testing with the French mountain rescue services, the first task was to confirm that it would not interfere with other equipment: radios, helicopter systems, avalanche beacons, or Recco sets. The device has a 2km range for an operator on the ground talking to a someone on the surface. It cannot be used in a helicopter due to the possibility of interference with the avionics.

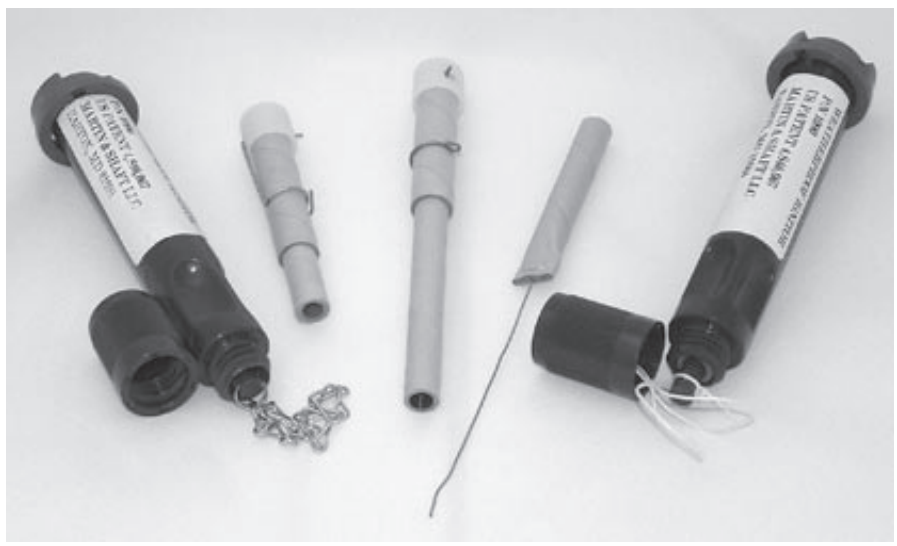
According to Diginext, cell phone signals can penetrate snow and are very directional. During testing, they have been able to pick up beacon signals under 2 meters of snow from a distance of 500 meters – a larger range than a ground searcher receives with an avalanche beacon.

The system can be used where there is no mobile phone coverage, which is frequently the case in the mountains. The Pic 2G can differentiate between the various cell phones within range. Given the widespread use of cell phones by backcountry travellers, this device could be a real advance in search and rescue, especially for people who are caught out by bad weather who could be given directions on how to seek shelter or how to provide basic treatment for injuries. This technology may change the directions frequently given by guides to turn cell phones off in the backcountry.

As an example, last year the Chamonix Mountain Rescue staff were in telephone contact with a stranded climber suffering from altitude sickness who could give no clear indication of his location. After 45 minutes of conversation, they lost contact with the climber, and despite a massive search operation they were unable to find him. With a Pic 2G system, the outcome may have been different.

Currently in development, this device will not be cheap – it will probably cost $40-50,000. But compared to the expense of a large search-and-rescue operation, this could be perceived as a relatively small one-time outlay.

Further information about Diginext can be found at www.diginext.fr, phone 04 42 90 82 82.



While the Martin & Shaft 2020 PWL *(center)* has been used in the avalanche-control industry for years, Martin and Shaft offers igniters of various configurations, including its patented WPI (weather-proof igniter) for rugged environments *(shown at left and right outside with chain or string pull)*.

PWL Manufacturer Merges & Moves to Maryland Production Facility

Martin & Shaft Company has been supplying the avalanche-control industry with low-cost, high-quality, pull-wire lighters/igniters (PWLs) since the 1960s. In January 2009, Martin & Shaft Company sold substantially all of its assets to a subsidiary of Orion Safety Products, a manufacturer and distributor of emergency highway and marine visual-distress signals, and is now operating under the name Martin & Shaft LLC. Orion Safety Products has its corporate offices in Easton, Maryland. You can find out more about Orion Safety Products at www.orionsignals.com.

The Martin & Shaft LLC business has recently completed relocation from Idaho Springs, Colorado, to Easton, Maryland, to leverage the technical expertise of Orion Safety Products in engineering, handling, and processing of energetic materials to exacting specifications. The production equipment and processes – as well as the quality standards the avalanche industry has come to expect from Martin & Shaft PWLs – remains the same.

The distribution and marketing of the PWLs, whether for the US, Canadian, or international markets, will remain under the direct control and management of Martin & Shaft LLC. Please contact Martin & Shaft customer service at customerservice@martinandshaft.com or call 303-567-4801 for additional information about the company's product line.

PORPHYRY PLACE:
The LaChapelle-Hunt Educational Homesite

Story by Bob Anderson and Bill Morris

(excerpted from a letter to the general snow and avalanche community)

You know about the many important contributions Ed LaChapelle made to the scientific study of ice crystals, snow movement, and glacial dynamics. You probably also know about Ed's lifelong efforts to make that science more accessible to the general public and to apply that knowledge to mountain safety, through his books *A Field Guide to Snow Crystals*, *The ABCs of Avalanche Safety* (co-authored in the latest edition by Sue Ferguson), and *Secrets of the Snow: Visual Clues to Avalanche and Ski Conditions*. And of course the book *Glacier Ice*, which Ed co-authored with Austin Post (and also showcases Post's photos), remains a classic for anyone interested in glaciers.

But you may not be aware of a unique memorial planned in Ed's honor, in recognition of his dedication both to education and to his adopted home of Alaska. We are writing to encourage you to make a financial contribution to make this memorial become a reality.

The Wrangell Mountains Center (WMC), based in McCarthy, Alaska, has a unique and time-sensitive opportunity to make a much-needed expansion of its facilities by acquiring the neighboring property that was for many years the primary residence of Ed LaChapelle and his partner, Meg Hunt. This property will be named Porphyry Place: The LaChapelle-Hunt Educational Homesite.

WMC is a private nonprofit institute that fosters understanding, appreciation, and stewardship of wildlands and mountain culture through scientific and artistic inquiry in Wrangell-St Elias National Park. Among other things, it has offered a college-level environmental education course each summer for over 20 years *(for more about WMC, visit wrangells.org/index.html)*. Both Ed and Meg served WMC for many years as volunteers, educators, and helpful neighbors. Ed's death in February 2007 has impacted WMC and the town of McCarthy in many ways. Ed was the wise old man in town, not in the least part because of the inspiration he provided with his solar-powered residence across the street from the Old Hardware Store in McCarthy (the home of WMC), and because of his inimitable skills as an ever-curious scientist of all stripes, an electrician, and a tinkerer.

Now, however, the WMC has the opportunity to purchase Ed and Meg's cabins and property across the street. Acquiring the LaChapelle-Hunt homesite would offer WMC many advantages to further its own mission and to support activities dear to Ed and Meg.

First and foremost, the main cabin would offer additional meeting space for courses and workshops to be held concurrently with activities in the Old Hardware Store. At present, space limitation prevents more than one activity at a time in the store, and as WMC's reputation grows, the demand for more programs continues to rise.

Secondly, other buildings on the property could provide temporary housing for artists or scientists in residence, or for visiting instructors of short courses and workshops. A recent example was a three-week Glaciology Field Course that was attracted to WMC by the nearby presence of Ed's beloved Kennicott Glacier, which reaches its terminus at the outskirts of McCarthy. Other courses could be offered in dance and yoga, activities Meg is actively engaged in. Instructor housing for such courses is severely limited in the Old Hardware Store.

Ed LaChapelle and Meg Hunt in front of their historic cabin in McCarthy, Alaska. With the help of generous donors, the Porphyry Place can become part of the Wrangell Mountain Center. *Photo by Rich Marriott, taken when Rich and Mark Moore visited Ed and Meg in McCarthy.*

Finally, the new space would offer WMC the opportunity to expand in new directions that are currently precluded by its limited facilities, such as family and youth programs for residents of the Copper River region, elementary and high school teacher recertification programs, and community workshops on sustainable cabin building and high-latitude gardening (taking advantage of Meg's outstanding garden).

WMC's tentative name for the facility is Porphyry Place: The LaChapelle-Hunt Educational Homesite. The title honors Porphyry Productions, the summer arts and lecture series that Meg and Ed founded and ran for many years in McCarthy, named after Porphyry Mountain, the scenic backdrop of McCarthy.

We hope you will help us make Porphyry Place a reality so that it can be a lasting legacy of Ed and Meg's dedication to education, and of their contributions to both WMC and their beloved town of McCarthy, Alaska. Photos and a video of the homesite along with more information about the fundraising campaign can be found at wrangells.org/porphyry%20place.html.

Make your tax-deductible donation to the effort to acquire Porphyry Place by mailing a check to Wrangell Mountains Center, 4822 Mills Drive, Anchorage, AK, 99508. Or make a secure donation online at wrangells.org/membership.html. **Make your contribution before the campaign closes on December 31, 2010.**

Bob Anderson, INSTAAR and Department of Geological Sciences, University of Colorado, Boulder, and Bill Morris, Biology Department, Duke University. Bill says, "I have done biological research in the McCarthy, Alaska area for nearly 20 years and was lucky to become good friends with Ed during that time."

Backcountry Avalanche Safety, written by long-time Canadian avalanche expert and AAA member Tony Daffern, is now available on amazon.com.

Longden Retires After 33 Years

Sylvan Pass Avalanche Program Director and Forecaster Maura Longden retired from the National Park Service at the end of November. During her 33-year career, Longden worked in more than a dozen national parks in the various roles of backcountry ranger, climbing and search and rescue ranger, district ranger, and chief ranger. She served as winter ranger in NPS avalanche programs in Yellowstone, Glacier, Yosemite, and Rocky Mountain National Parks.

Longden is a former Big Sky ski patroller, backcountry ski guide, and avalanche search dog handler. Her husband, Rich Baerwald, will continue as lead avalanche forecaster and park ranger in Yellowstone National Park. For the immediate future, Maura plans to base out of the couple's home in Victor, Idaho, and enjoy an abundance of great skiing in the Teton Range.

Kevin Hammonds will be joining the Sylvan Pass staff in one of the avalanche forecaster positions. Hammonds is currently attending the University of Utah working towards his degree in atmospheric science. He previously ski patrolled at Park City, and he currently works as a climbing ranger at Mount Rainier National Park during the summer.

(l-r): Rich Baerwald and Maura Longden take a break in Yellowstone National Park.

Wet-Snow Seminar Tackles Tough Questions

Story by Scott Savage

The Gallatin National Forest Avalanche Center hosted a wet snow and avalanche professional development seminar in Bozeman, Montana, this spring on March 5. Ski-area forecasters and patrollers, highway forecasters, backcountry forecasters, educators, researchers, graduate students, an NRCS employee, and a snow ranger attended the day-long event. The participants' diverse backgrounds along with the small class size (roughly 25) helped generate several interesting discussions.

Recent Montana State University PhD graduate Andrew Slaughter began the day with a presentation that answered some basic but crucial questions: What is wet snow, and how does it get that way? Slaughter covered the fundamentals of wet snow and made energy balance at the snow surface understandable for the non-scientists at the seminar. Using examples from his cold lab work, he highlighted the challenges of understanding and measuring radiation exchange at and near the snow surface. Several participants noted that this was the best energy exchange presentation that they have seen – kudos to Andrew for making a very complex subject understandable for practitioners!

Scott Savage's presentation, *Wet-Avalanche Basics and Wet-Loose Avalanches*, began by characterizing wet avalanches and briefly examining wet-loose, wet-slab, and glide avalanches. Scott stressed that wet snow is fundamentally different than dry snow in that it generally fails due to decreasing strength in an existing layer of the snowpack rather than due to increasing load on the snowpack. He also covered wet-loose avalanches and forecasting and the operational challenges that they present. While it is very difficult to accurately forecast the timing of wet-loose avalanche activity in specific avalanche paths, wet-loose avalanche hazard can be effectively managed (both actively and passively) through diligence.

Erich Peitzsch of the USGS Rocky Mountain Science Center spoke on several topics. Peitzsch's first talk, *Recipe(s) for a Wet-Slab Avalanche…and other ridiculous wet snow phenomena!*, investigated how free water moves through the snowpack. During Peitzsch's graduate studies at MSU, he found that fine grains overlying coarse grains (commonly old facets) created capillary boundaries that caused water to flow laterally in the snowpack instead of draining. Stratigraphic observations of several large, wet-slab avalanches showed this snowpack setup. Peitzsch noted that snowpacks with this layering scenario are capable of producing wet-slab avalanches if the "water factory" (the melting portion of the snowpack) generates enough free water that makes it to the "funny business" (the old facets) before the snowpack establishes good drainage. Peitzsch and Karl Birkeland both noted that forecasters may find it useful to view periods of rapid melt as "storms" capable of initiating avalanche activity, especially during the first major warmup/melting event of the spring. Peitzsch also spoke briefly about glide avalanches and how even less is known about them – good luck with those!

Peitzsch's next talk covered forecasting operations and wet-snow avalanche activity near Glacier National Park's Going-to-the-Sun Road. Each spring, heavy equipment operators work to clear this road for the summer tourism season. As the road bisects the tracks and run-out zones of several large 1000m+ avalanche paths, forecasters play an important role protecting road-clearing crews. Glacier NP forecasters have observed and studied several wet-slab cycles over the past seven years, and they are making headway in characterizing snowpack and meteorological conditions that tend to produce glide and wet-slab avalanche activity.

Don Sharaf's presentation highlighted what he's learned during years of operational and industrial experience dealing with wet snow and avalanches in different snow climates. Sharaf highlighted guiding strategies that he's fine-tuned over the years as well as wet-slab and glide avalanche mitigation techniques. Sharaf's work on the Snettisham powerline project outside Juneau, AK, was especially enlightening. He shared tales of unsuccessful attempts to release wet-slab and glide avalanches with both large explosives and by heli-dumping bambi buckets of water onto the snowpack and into glide cracks. Sharaf also observed that, historically, the biggest snow years usually do not produce the worst wet-slab problems.

Tom Leonard presented a ski-area forecaster's perspective on wet-avalanche forecasting and mitigation. The Yellowstone Club has several paths within the ski area that produce wet activity both during and after the scheduled ski season. Additionally, a maintenance structure and propane station is located underneath a path that has produced several wet-slab events. Leonard entertained the group with stories about their struggles to mitigate this hazard without "rearranging" structures or propane tanks. The Yellowstone Club ski patrol has been successful at triggering wet-slab avalanches with explosive air blasts on several occasions. Leonard also shared details of a surprise event that released at 8:30am following a hard freeze the previous night.

Erich Peitzsch then spoke on *Climate Change and Avalanches in the Northern Rocky Mountains*. This presentation focused on the potential for climate change to alter avalanche activity. While it may be easy to assume that warmer mean temperatures would cause an increase in wet-avalanche activity, the relationship is actually far more complex. Climate change would likely alter forest health and distribution on large scales, and avalanche size and frequency is highly dependent on vegetation type and distribution. Peitzsch and Dan Fagre of the USGS plan to devote a lot of time studying climate change's potential effects on avalanche activity in the future.

The Big Bend slide path, on the Going to the Sun Highway in Glacier Park, Montana, was one of more than a dozen slide paths that released during a wet-slab cycle in April, 2003. Water factory, dry slab, and funny business were present in abundance. *Photo by Karl Birkeland*

A group panel spent 30 minutes tackling several thought-provoking questions such as, "How long does a given wet-slab instability persist?" and, "'Slopes are dangerous when you're sinking into wet snow up to your boot tops: sage advice or an old wives' tale?" Several open-ended questions stimulated excellent discussion; this portion of the seminar could have easily gone on for hours.

Karl Birkeland concluded the seminar by contrasting wet-loose and wet-slab avalanches and reviewing what we know and don't know about them. Birkeland highlighted the difficulty in pinpointing the expected timing of wet-loose avalanche activity, especially on regional scales. He reiterated that wet-loose issues are generally manageable for individuals and operations, but wet slabs remain poorly understood and currently are somewhat "unmanageable." We understand many of the conditions that tend to be associated with wet-slab activity, but we lack the wet-slab data and observations needed to accurately and confidently forecast and/or mitigate this hazard.

Workshop participants and organizers considered the day a rousing success. The diverse speakers and crowd ensured that wet snow and avalanches were examined from varying points of view. Organizers feel that the different perspectives presented by researchers, practitioners, educators, etc., combined to make this an invaluable learning opportunity.

The GNFAC, with financial assistance from the AAA, plan to host another professional development seminar in early March 2011.

Scott Savage is the Intermountain North section representative to the AAA board. A long-term knee injury has given him time to write and organize. The Avalanche Review *wishes Scotty swift healing, although we have been a consistent recipient of his snow-related project work.*

This historic ski moment was captured by Bob and Ira Spring at Paradise on Mt Rainier in 1948. *Photo courtesy Spring Trust for Trails*

Skoog Publishes Washington Backcountry Ski History Book Online

Ten years ago I began researching the history of backcountry skiing and ski mountaineering in Washington. When I started my research, I hoped to eventually publish a book in print. I still plan to finish the book, but I've given up the print side of it. Instead, I've published the first chapter of the book online. This will ultimately be Chapter 4 (or so) in the finished story. It's called *The Ski Climbers*, and describes an iconic period in Northwest skiing: the years between 1928 and 1948 when pioneering ski ascents and descents were made on Mount Baker, Mount Shuksan, Glacier Peak, Mount Rainier, Mount Adams, Mount St Helens, and Mount Hood.

The book will ultimately encompass about a dozen chapters. *The Ski Climbers* illustrates the kind of coverage I hope to achieve for the 100-year history of backcountry skiing in Washington. Publishing online enables me to include more stories, more pictures, and more diverse media than in a traditional book. For instance, *The Ski Climbers* contains movies, and future chapters may include other multi-media material. Publishing online will also enable me to add new information, make corrections, and publish something before I reach retirement age. I'm excited about this approach.

You can find this new chapter on the Web site devoted to the book at written-in-the-snows.net. I hope you enjoy the first chapter.

—Lowell Skoog

education

THE ABCs (and D) OF DIGGING:
Avalanche Shoveling Distilled to the Basics

Story & Photos by Bruce Edgerly

It's not sexy, but it sure saves lives. Over the past four years, shoveling has become an increasingly important aspect of recreational and professional avalanche courses. Real incidents have occurred in which shoveling strategy made the difference between life and death *(Weselake, et. al., 2008)*. After four years of instruction and feedback, however, it's time to re-evaluate and optimize these techniques so they're easier to teach and execute.

Educators have adopted two prevailing techniques: "strategic shoveling" and the "V-shaped conveyor method" – with various hybrid approaches in-between. We surveyed 90 North American avalanche instructors to determine how these techniques are working in the field and how they can be refined.

From this survey and subsequent field sessions in Colorado, we distilled prevailing techniques down to four key concepts that can be remembered with a simple mnemonic: the "ABCs (and D) of Digging." We created a concise educational video illustrating these four basics:

A preserving the **AIRWAY** *(A)*,

B using **BURIAL** *(B)* depth to define the excavation area,

C **CLEARING** *(C)* snow to the sides first,

D and **DIGGING** *(D)* snow only once.

SURVEY FINDINGS

Strategic shoveling and the V-shaped conveyor represent major advancements in avalanche rescue technique. But there is confusion about which methods are appropriate for which user groups and how relevant they are when taught to the wrong audience. For example, a recent survey of 97 avalanche rescue incidents in North America *(Edgerly, 2010)* indicates that avalanche debris is generally not hardened enough in companion rescues to justify the prying, paddling, and shoveling redundancies inherent in the V-shaped conveyor. Likewise, when manpower is unlimited, strategic shoveling does not provide the level of organization that might benefit a large search-and-rescue operation.

To assess the effectiveness of current techniques – and attempt to bridge the gap between them – we conducted an online survey of North American avalanche educators. We emailed the survey to professionals in the AAA and AIARE instructor pools in the US and to the AST instructor pool in Canada. We received complete responses from 90 instructors.

The survey led to the following conclusions:

1. Strategic shoveling is often considered more appropriate for companion rescues with limited manpower. It is taught widely in the US and has been adopted by AIARE and the National Ski Patrol for companion rescue. The V-shaped conveyor is often considered more appropriate for larger groups, including search-and-rescue teams and mechanized guiding operations, which often have more manpower. It is taught more widely in Canada, where mechanized guiding is more prevalent.
2. Many instructors are unclear on the differences between the two techniques: some teach strategic shoveling, but call it the "conveyor method" and vice versa.
3. Some instructors teach both techniques but customize their instruction to the group being taught.
4. Numerous instructors cited an unnecessary dichotomy between the two techniques. They stressed that they share many common elements and these should be reinforced instead of the finer points that distinguish strategic versus V-shaped technique.
5. Very few instructors said they do not teach shoveling technique at all. Some instructors thought it was even more important than transceiver instruction, considering the time spent excavating versus beacon searching in real avalanche scenarios.

The ABCs (and D) of Digging

The conclusions from our survey clearly indicate that the shoveling techniques currently being taught are extremely valuable, but are unnecessarily divergent and possibly more complicated than necessary for the majority of avalanche-rescue trainees. We distilled the concepts most widely adopted by the survey respondents down to four key points, easily remembered with the mnemonic: the ABCs (and D) of Digging.

A = Airway

- Protect the airway by leaving the probe in the snow at the probe strike and performing the excavation downhill from this point. Do not step in the area uphill of the probe, as this increases the probability of compacting the victim's air pocket.
- Complex terrain features such as obstacles and terrain traps may require approaching from other angles.

B = Burial Depth

- The long axis of the excavation area is defined by the victim's burial depth. The slope angle of the majority of avalanche depositions is in the range of 5-15 degrees. Therefore, in the majority of avalanches, the excavation area should extend downhill 1.5 times (1.5x) the burial depth. This can be adjusted to 2x burial depth in flat debris piles or 1x for slope angles greater than 20 degrees.

The excavation area should extend downhill of the probe about 1.5 times the burial depth, as shown in this photo. However, in shallow burials of less than one meter, all resources should be focused on the immediate vicinity of the probe, to maximize the chance of revealing a body part.

- In burials less than one meter deep, no offset is necessary, even on horizontal slopes. The priority should be to locate the airway as soon as possible rather than maintaining an adequate excavation size. In such shallow burials, all resources should be focused on digging in the immediate vicinity of the probe – without compromising the victim's airway.
- Burial depths greater than two meters might require moving snow more than once, using an in-line or V-shaped formation.

C = Clear Snow to the Sides

- Always begin the excavation by moving snow to the sides of the hole rather than downhill. This prevents the downhill side from building up and preserves it for snow removal as the hole becomes deeper. By moving snow to the sides, rescuers will minimize the necessity to move snow more than once as the hole gets deeper.
- The width of the hole is defined by the number of rescuers available, not by burial depth. It is always preferable to concentrate resources (at least two shovelers) at the probe strike. This increases the probability of revealing a body part, and it prevents the hole from becoming too narrow. However, it is inefficient to excavate wider than 6' (two meters); the probability is low that the victim's position will be exactly perpendicular to the fall line.

All excavations should begin by clearing snow to the sides. In this case, three shovelers are available. Two are focused on the probe area with the third taking the "secondary" role 1.5x burial depth downhill.

The hole can be made wider, if necessary, once the victim's position is established. In this case, only the snow immediately surrounding the victim will need to be moved – not the snow that has been cleared to the sides. This is because the "bridging effect" of work-hardened snow will prevent the undermined area from collapsing.

D = Dig Only Once!

- Unless manpower is unlimited, it is inefficient to move snow more than once. Only in the most hardened debris – and the deepest burials – should a block of snow be handled more than once or by more than one person.

Shoveling on one's knees can be more ergonomic than standing. Once you start bending over too far (shown above), stand in the excavated area and move the snow that was under your knees. This should be cleared to the sides, if possible, to ensure that it's only moved once.

Conclusion

By teaching shoveling strategy and technique in their courses, avalanche educators have made great strides in improving the odds of survival in real avalanche scenarios. Four years of instruction and feedback, however, have shown that the two prevailing techniques being taught are unnecessarily divergent and complicated. By distilling the most important concepts down to the fundamental ABCs – and clearly illustrating them with a downloadable video – we believe educators will teach shoveling technique more effectively and that more lives will be saved into the future.

Shoveling snow might not be sexy, but saving lives sure is!

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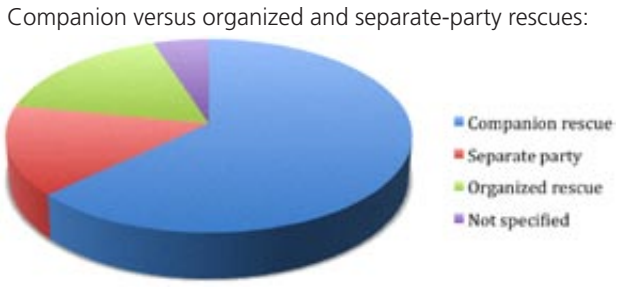
Bruce Edgerly is vice president and co-founder of Backcountry Access, Inc. (BCA)

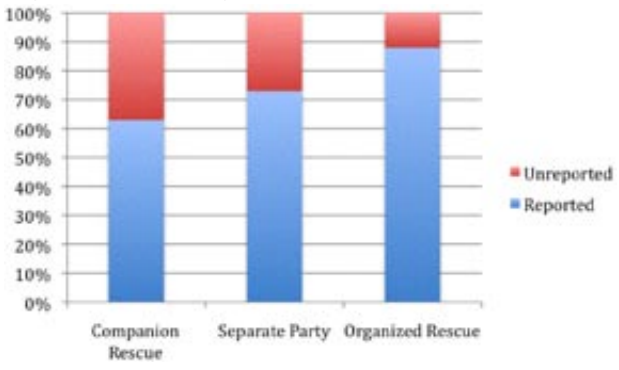
media

In May 2010, 20-year-old snowmobiler Nic Roche deployed his airbag and survived an avalanche near Anaconda, Montana. Like many avalanche survivors, Roche did not report the incident. Since there were no injuries or fatalities, there were no authorities or medical agencies involved. *Photo courtesy Jack Jones*

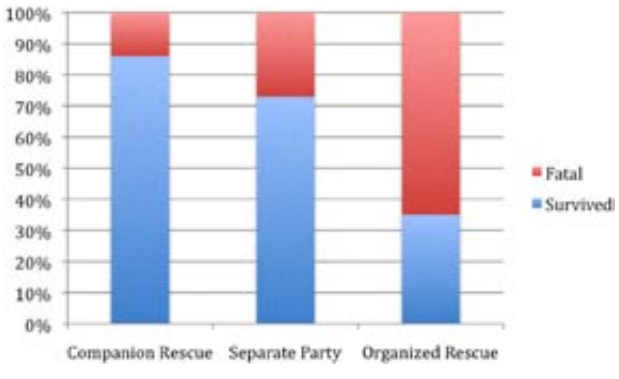
Companion versus organized and separate-party rescues:



Reported versus unreported incidents:

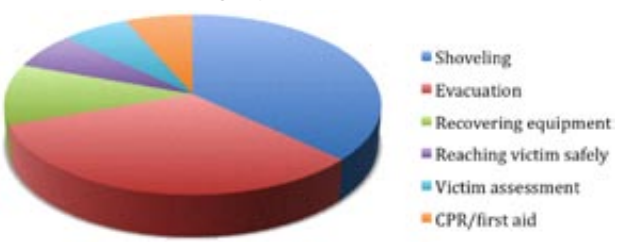


Survival rates of companion, separate-party, and organized rescues. This includes all incidents, including those not involving complete burials:

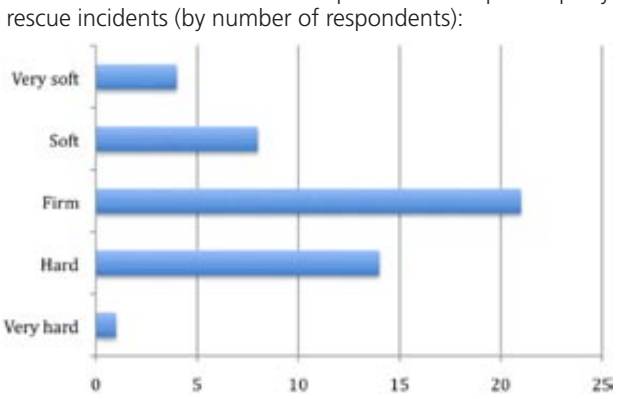


Number of buried victims:

Most time-consuming aspects of the search:.



Relative debris hardness in companion and separate-party rescue incidents (by number of respondents):



UNDER THE RADAR:

Using "New School" Media to Capture Unreported Avalanche Incidents

Story by Bruce Edgerly

Editor's note: We look forward to future research within this family of accidents and stories, especially in the realm of decision-making and human factor. What are the vital differences between near misses and fatalities?

Unless you're a sheriff or coroner, it's not easy getting details on avalanche incidents. Many success stories go unreported, skewing publicly available statistics toward fatalities, traumatic injuries, and worst-case scenarios. The growing social media environment, however, provides instant access to those who have been on the ground in avalanche incidents, whether or not these incidents were reported. This can provide valuable insights into what's really happening on the debris pile: techniques and gear that are working and not working, human factors in avalanche rescues, and what the real-life challenges are in "live combat."

Through North American social media, including internet forums, blogs, and Facebook pages, we gathered information from 97 respondents that have been in avalanche rescues – in many cases, live recoveries. Our key findings: 1) almost 40% of the companion-rescue incidents went unreported; 2) a surprising 27 of the 97 respondents (28%) had performed live recoveries with avalanche beacons, almost a third of which went unreported; and 3) shoveling and evacuation were the most time-consuming phases of most incidents.

TRADITIONAL STATISTICS

Reports on avalanche statistics traditionally have been based on incidents documented by avalanche centers, sheriff's departments, and coroner reports. Examples include papers published by this author *(Edgerly, 2008)* and by Dieter Stopper *(Stopper, 2008)* at the 2008 International Snow Science Workshop.

Both these papers analyzed several years of statistics in North America and Tyrol, Austria, focusing mainly on multiple-burial incidents. Statistics were gathered from reports made available from avalanche centers. During the analysis, however, it became obvious that the reports available to the public mainly involved fatalities and hospitalizations, and that many avalanche-rescue incidents were not being reported. This can severely skew statistics toward worst-case incidents, including the deepest burials, incidents without transceivers, major trauma cases, and incidents with multiple victims.

Written reports also do not always contain enough detail to be of value to avalanche researchers, scientists, or snow-safety manufacturers. In an attempt to get further details on the incidents regarding search times, excavation times, and other factors, both authors attempted to interview the individuals involved in the incidents. This was quite difficult, as none of these reports contain contact information for the rescuers or the buried persons. This had to be obtained by other means, including phone directories and Internet search engines. After analyzing the statistics and interviewing as many involved parties as possible, the authors concluded that shoveling – not beacon searching – was the crux of most avalanche rescues, including multiple burials. They also both pointed out that the study was somewhat skewed toward worst-case incidents. We determined that to get a clearer picture of what was really going on in real avalanche rescues – including successful recoveries – it was necessary to reach out directly to those involved instead of going through published incident reports. In recent years, this has become much more realistic with the rapid adoption of Facebook and other social media networks.

SOCIAL MEDIA SURVEY

In the winter of 2010, we developed a survey that included roughly 75 questions about what equipment, techniques, and organizational methods were used in avalanche incidents involving burials. This was created through independent contractor Survey Gizmo, and respondents were recruited from over 25 social media networks. This included blogs, forums, and Facebook pages including Wildsnow.com, Tetongravity.com, Telemarktips.com, Biglines.com, Mountainproject.com, Transworld Snowboarding, National Ski Patrol, AIARE, Snowest.com, and Snowandmud.com. We attempted to get the survey out to a wide range of both recreational and professional backcountry users, to minimize any potential bias that could be created by a preponderance of responses from one user group over another. This survey was made available to snowmobilers as well as skiers, snowboarders, and climbers. The objective of the survey was to analyze a better cross section of incidents than the 2008 research, which focused on published reports and multiple-burial incidents. The motivation was to determine what the most important issues are in avalanche rescues and what can be improved in the way of equipment, training, or education to increase survival rates.

SURVEY RESULTS

Since the survey went out to such a wide cross section of recipients, it was necessary to segment the responses by rescue type in order to provide better resolution. About two-thirds of the respondents were involved in companion rescues (63%) involving members of their own party. 15% were involved in a search for someone from another nearby party. 17% of the respondents came from participants of organized search-and-rescue (SAR) teams called to the scene well after the accident took place.

Reported Versus Unreported Incidents

Of these groups, companion rescues were the least likely to be reported. Nearly 40% of these went "under the radar." Only 12% of the organized rescues went unreported. These mainly involved injuries and non-complete burials.

The likelihood of the incident being reported is highly dependent on the outcome of the rescue. All incidents were reported if they involved fatalities. However, of incidents involving complete burials, 40% of the successful live recoveries were not reported.

The overall fatality rate was 28% in our survey. Of reported incidents, the fatality rate was 41%. Of unreported incidents, the fatality rate was zero, as mentioned above. These statistics support our belief that published reports are skewed toward worst-case incidents.

Survival Rates

As can be expected, companion-rescue incidents had the highest survival rates. Organized rescues were the least successful, the obvious reason being their longer response times. The survival rate was zero for complete burials involving organized rescues that were not within or adjacent to a ski area.

The cause of fatality was cited as asphyxiation in the majority of incidents. Of course, none of the respondents were coroners, so this data is inexact. Trauma was cited in less than half the incidents. Both trauma and asphyxiation were cited in several cases.

Number of Victims

Just under half of the incidents involved complete burials with no surface clues. Just 6% of the incidents (12% of the complete burials) involved multiple buried victims. This is slightly lower than the 14% that we reported in our 2008 research.

Of these complete burials, just four involved multiple-victim beacon searches. Two respondents reported complications in the beacon search due to multiple signals. These both involved searchers using analog transceivers.

Overall Incident Time

Shoveling and evacuation, respectively, were by far the most time-consuming aspects of the incidents

in our survey. This was followed by recovering equipment, reaching the victim safely (most often due to secondary avalanche hazard), victim assessment, and CPR or first aid.

Debris Hardness

Although shoveling was cited as being very time-consuming, the debris was not as difficult to penetrate as is often described. There were very few cases where the debris was characterized as "very hard." In fact, in non-organized rescues, the debris was described as "very soft" more often than it was described as "very hard." The bulk of respondents described the debris as "firm" and "hard."

In organized SAR responses, only one respondent described the debris as "very hard." When asked by telephone, he said the snow could be moved simply by chopping and shoveling and did not require prying, as is sometimes taught in specialized training courses.

One of the more surprising results of the survey was that there were no incidents in which shovels were broken. Two respondents said they bent their shovels and five respondents said their plastic shovels were not very effective. But there were no complete failures.

Rescue Management/Site Control

In the area of overall rescue management and site control, secondary avalanche hazard was cited the most often (17 incidents) as complicating the search, followed by lack of leadership or communication (9 incidents), renegade signals (6 incidents), and panic/chaos (5 incidents).

Secondary hazard and group leadership are part of most avalanche trainings. However, an important additional point is that signals being transmitted from people above the surface, within the searching parties, were cited three times more often for complicating a search than signals from multiple buried victims beneath the surface.

Transceiver Rescue Times

Another interesting point is that the beacon search is cited very rarely as a complicating factor in avalanche rescues. In six complete burial cases, the victim did not have a transceiver. But in the remaining incidents, the average search times were on the order of five minutes from the beginning of the signal search (if applicable) to the probe strike. This does not include organized rescues and two companion rescues in which there was a delayed response due to long distances between members of the involved party.

The coarse search was the most time-consuming phase of the beacon search process, consuming an average of just under three minutes versus less than 90 seconds each for the signal, fine, and probing phases.

It should be noted that all times provided by respondents were estimates and are therefore not precise. The perception of time, furthermore, can vary widely between individuals, especially under stress.

These times include both live recoveries and fatalities. If you analyze the times for live recoveries versus fatalities from asphyxiation, then it is clear that burial depth and excavation time – not beacon search time – make the difference between life and death (assuming beacons are used; otherwise, fatality is guaranteed).

Airbags and AvaLungs

With the paramount importance of burial depth and excavation time, it makes sense to analyze the effectiveness of newer devices that strive to mitigate these issues, such as avalanche airbags and AvaLung systems. Avalanche airbags are designed to keep the potential victim on top of the debris, to prevent burial. The AvaLung is designed to prolong the amount of time a buried victim can survive after burial.

Avalanche airbags were deployed by seven people caught in avalanches. Six of those seven stayed on the surface and survived with no injuries. The seventh person was pushed through trees and his airbag punctured. He died from asphyxiation.

In five incidents, the buried subject was wearing an AvaLung. In two cases, the victim kept the mouthpiece in his or her mouth and could utilize the device after burial. In three cases, however, the user was not able to keep the mouthpiece in, so was not able to take advantage of the device.

CONCLUSION

By using social media to go directly to those who have been in real avalanches, we have been able to capture many incidents that previously flew "under the radar" of traditional avalanche reporting.

Secondary avalanche hazard, leadership, renegade transmit signals, shoveling, and evacuation are the real challenges for those facing "live combat" on the debris field. These are important subjects that avalanche educators should emphasize in their avalanche courses.

The most encouraging finding in this study could be that, hidden among the annual procession of highly publicized avalanche fatalities and injuries, there are a surprising number of unreported success stories. With greater opportunities for education, the growing adoption of preventative safety devices like airbags, and the rapidly growing use of social media, we may be hearing about even more success stories in the future.

Instead of getting our reports from sheriffs, coroners, and faceless databases, we can now hear and learn directly from those who have engaged in real avalanche rescue combat. By getting their inspiring examples out to the public, we can further motivate backcountry users to get educated, learn good decision-making, and practice with their safety equipment.

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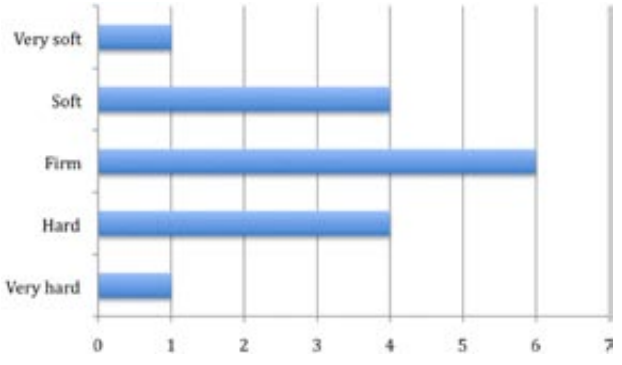
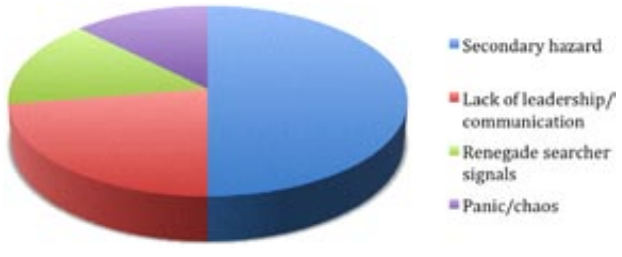
Stopper, D. and Mullen, J., 2008. *Specialized Multiple Burial Techniques: Reality Versus Myth; the European Perspective*. ISSW Proceedings, 2008.

Bruce Edgerly is co-founder and vice president of Backcountry Access (BCA), a leading manufacturer of snow-safety equipment, including transceivers, shovels, probes, and avalanche airbags. He presented "Under the Radar" at ISSW 2010 at Squaw Valley.

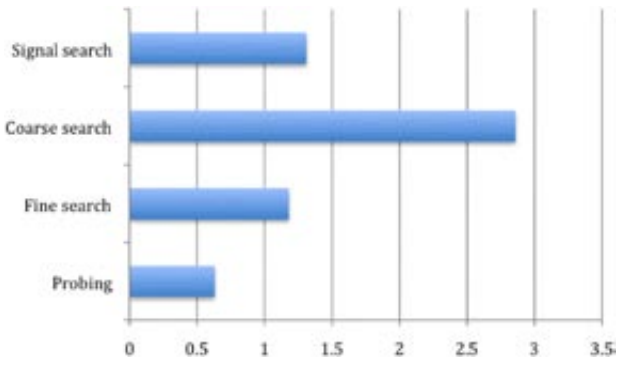
Debris hardness in organized rescue incidents (by number of respondents):



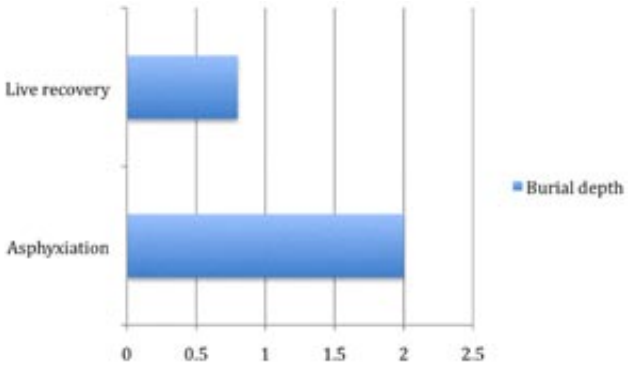
Rescue management issues cited:



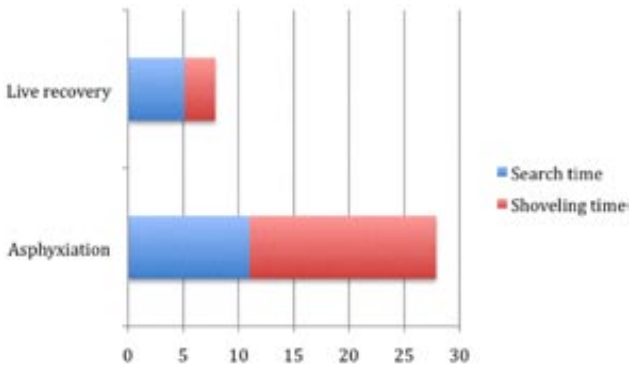
Average transceiver search times (in estimated minutes) for companion and separate-party rescues:



Average burial depth (in meters) for live recoveries and fatalities by asphyxiation; non-organized rescues:



Average beacon search and shoveling times (in estimated minutes) for live recoveries and for fatalities by asphyxiation; non-organized rescues:



snow science

AIEEEE!!! La Niña!

Story by Mark Moore and Rich Marriott

Much like last year when thoughts of an El Niño winter resulted in joy for some and dire predictions of a horrible snow year for others, this past summer the talk has been of a "strengthening moderate to strong" La Niña. And as of this writing in October, forecasters are now talking of the strongest La Niña in over 50 years. Over half of the computer models used to forecast El Niño/La Niña are predicting La Niña to "become a strong episode by the November-January season before beginning to weaken." This talk may have some folks wondering exactly what weather and related snowpack ramifications might be in store for their area.

Weather climatologists who dwell in the land of long-range predictions wish there was an easy and clear-cut answer to this question (as do longer-range avalanche forecasters), but like most things dealing with the future, all answers come with a bucket of qualifications.

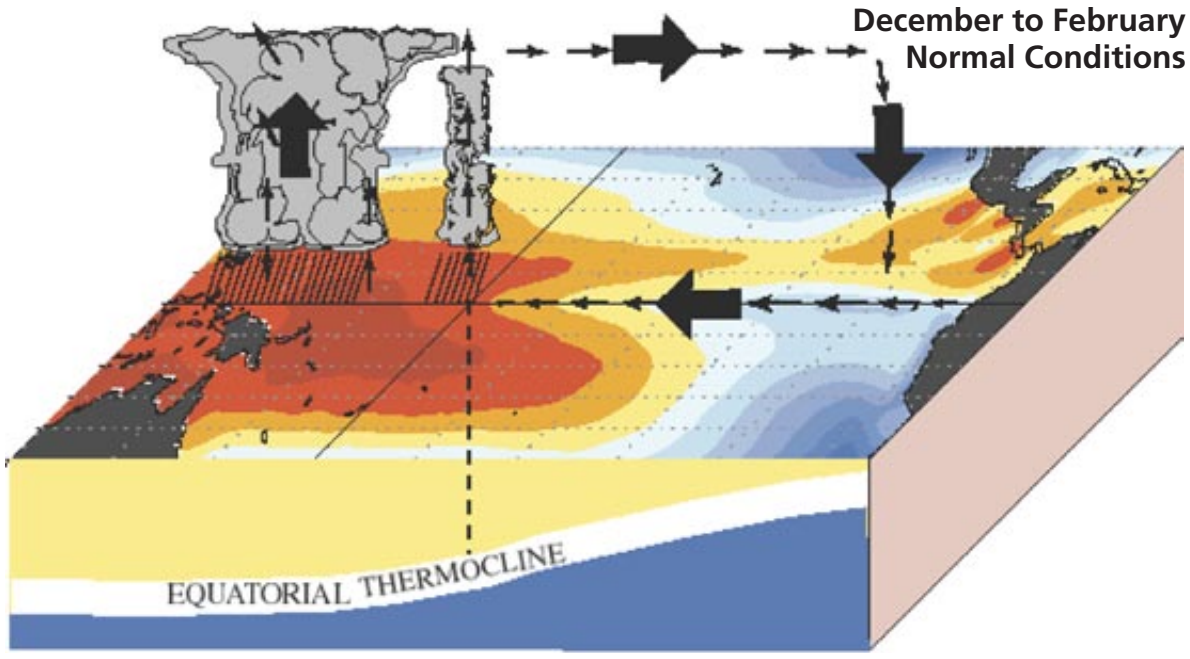


Figure 1: Easterly trade winds push warm water into the western Pacific allowing upwelling off of South America to bring up cooler water. *diagram courtesy NOAA-NCEP*

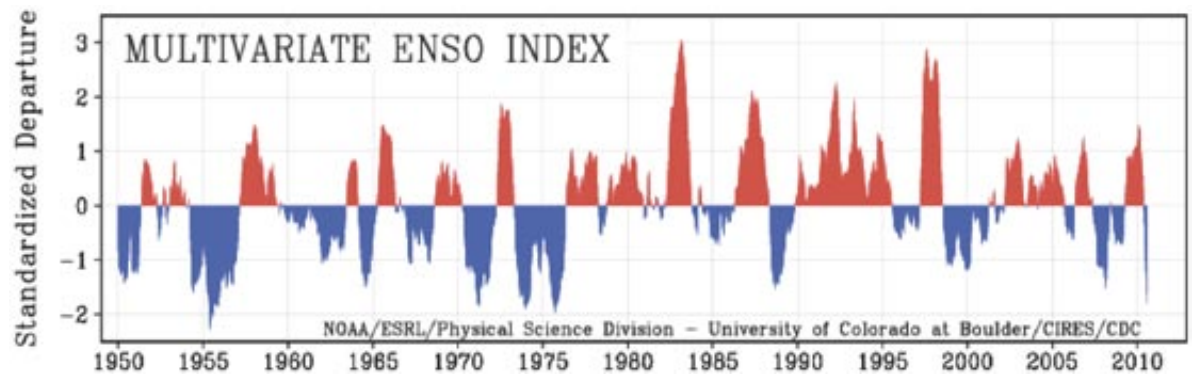


Figure 3: ENSO event chronology from 1950-present. Red generally reflects a warm event or El Niño, Blue reflects a cool event or La Niña.

A Little Background

La Niña and El Niño are different phases of the same phenomenon called the ENSO (El Niño - Southern Oscillation). Although we usually talk about ENSO in terms of changes in tropical sea-surface temperatures, it refers to a whole set of atmospheric and ocean patterns that shift in a semi-regular fashion and affect weather all around the globe. In fact, besides the seasons, ENSO is the most powerful driver of global weather changes currently known.

Anatomy of ENSO

Under average conditions the trade winds blow from east to west (easterlies) across the Pacific, which has some of the warmest waters in the world *(see Figure 1, above)*. As they blow, friction between the wind and the sea surface push or drag the surface water towards the west. Along the South American coast it strips off the surface warm water and shoves it west piling it up in the western Pacific near the Philippines – in fact sea level in the Philippines is about 2' higher than near South America.

As this warm water is pushed westward it is replaced by the cold water upwelling from lower depths lowering the sea surface temperatures. Thus under "normal conditions" we see a pattern of cool water in the eastern Pacific and warm water in the west.

When an El Niño occurs, the easterly trade winds (which are driven largely by the temperature differences between the poles and the equator) weaken and can even turn westerly. Initially this allows warmed surface water in the eastern Pacific to stay in place, and then eventually, the increased warm water in the western Pacific is able to flow back to the east. This leads to rising sea surface temperatures (SSTs) from the central Pacific all the way to South America *(see Figure 2, below)*.

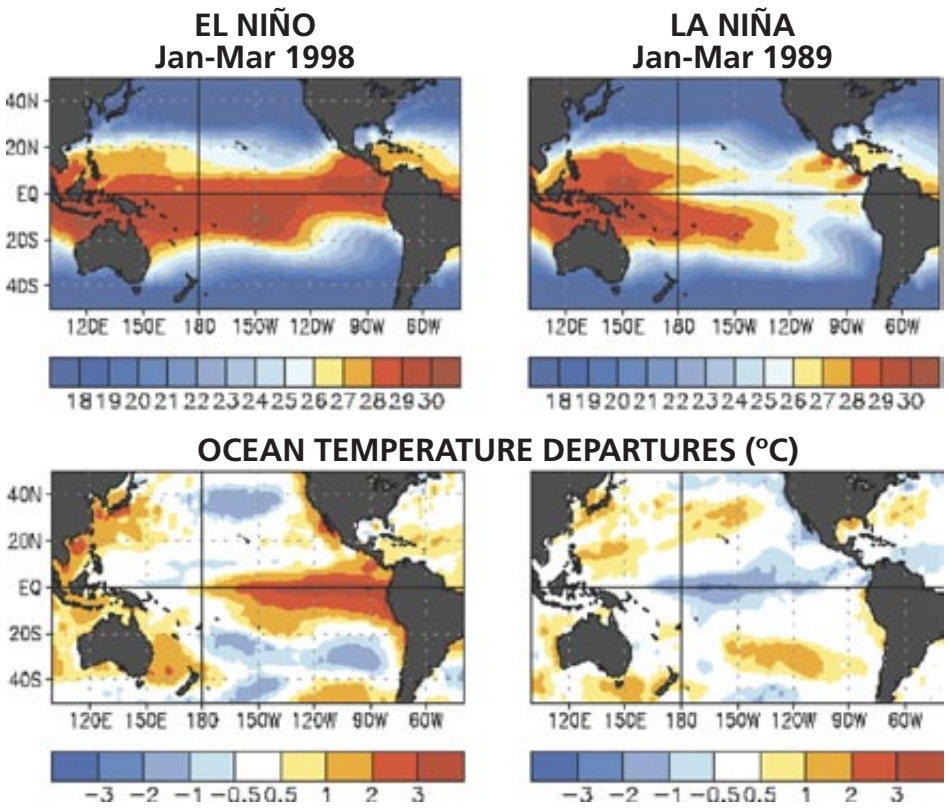


Figure 2: Sea surface temperature patterns associated with El Niño and La Niña. *diagram courtesy NOAA*

When a La Niña occurs, the easterly trade winds actually strengthen and even more of the surface water is stripped away in the central and eastern Pacific and pushed towards the Philippines, causing a tongue of cooler than normal water to extend westward across the central Pacific *(Figure 2)*.

Although we talk of sea surface temperatures, measurements of water temperatures at depth indicate that these departures from average extend downward to the thermocline – the boundary that separates the well-mixed surface water and the stratified deep cold water. This boundary tends to be about 130' deep off of South America and anywhere from 330'-660' deep in the western Pacific near New Guinea. In fact what we are observing is a gigantic pool of very warm water that can move back and forth across the Pacific and strongly affect mean weather patterns.

Due to better worldwide atmospheric and ocean data being fed into improved computer models of the atmosphere-ocean interaction, forecasts of ENSO are gradually improving, but what initiates and ends episodes in the first place remains a matter of intense research.

El Niño has a natural periodicity of roughly three to four years, with episodes generally lasting 12-18 months and the strongest events occurring every 10-15 years. Meanwhile, La Niña episodes may occur less frequently than El Niños and may last from one to three years *(see Figure 3, above)*. In most changeovers between ENSO events, the transition from El Niño to La Niña is often more rapid and dramatic than La Niña to El Niño. And this is particularly true with the current event, which has not only evolved quickly but is of a relatively high magnitude – perhaps the strongest since La Niña 1955/56.

The International Research Institute for Climate and Society indicates past La Niñas that are similar to the evolution of the current one include 1970/71, 1973/74, and 1998/99. If you are a forecasting aficionado, you might want to check how those winter seasons developed in your neck of the woods to provide a first-guess forecast of the coming winter. You might also review the winter storm activity that occurred during the other moderate to strong La Niña events since 1949, which include 1949-50, 1954-56, 1964-66, 1970-72, 1974-75, 1975-77, 1988-90, 1998-2000, and 2007-09. However, recent research is suggesting ENSO events since 1970 may affect weather patterns differently due to climate change.

What's Ahead This Winter?

As it is almost certain that the winter ahead will be dominated by a moderate to strong La Niña, what exactly does that mean for the weather in the West?

During each ENSO phase, the path of the Pacific and polar jet streams as they cross the Pacific and into North America have a mean route along which they steer storm systems. In the past, La Niña has displayed a tendency for the energy going into these jet streams to fluctuate between two different paths *(as shown in Figure 4)*. It's evident that air traveling these routes will cross widely different moisture and temperature regimes, producing much different weather. In addition, these mean paths will not affect all regions of the United States in the same way.

When the main jet stream lies along the lower (red) track shown in Figure 4, gloriously rainy/snowy Northwest weather brings delight to both woodland creatures and lovers of Cascade crud. Whatever residual moisture makes it out of the Pacific Northwest continues on across the northern tier of the US through Idaho and into Wyoming and Montana, but somewhat less abundantly. Some of these storms may reach into northern Utah and northern and north-central

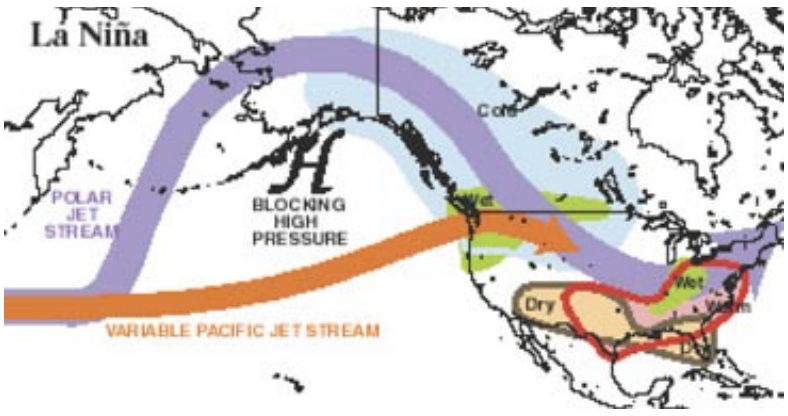


Figure 4: Typical upper-level flow and associated weather patterns in the Pacific and US during a La Niña episode.

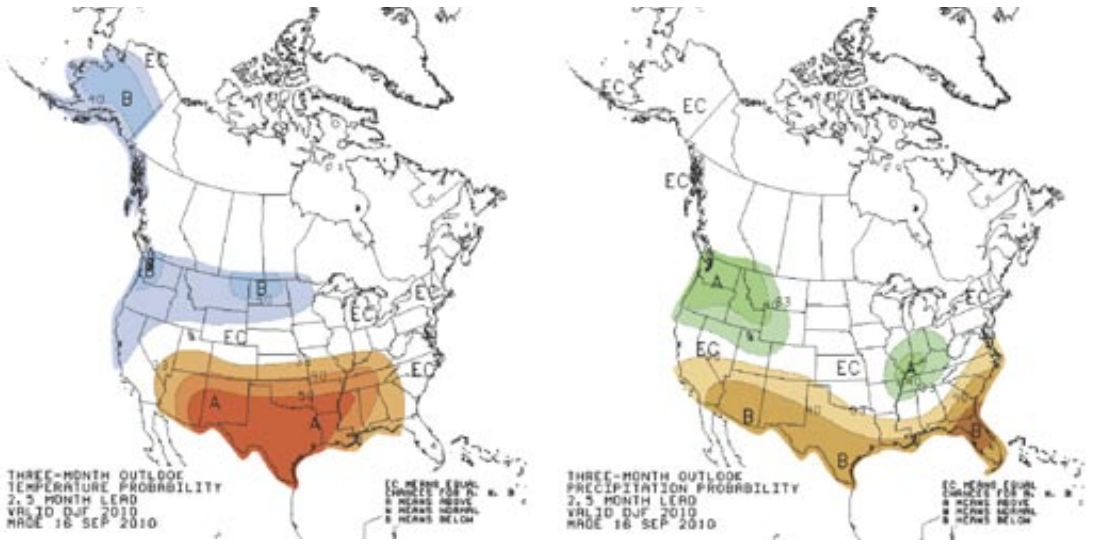


Figure 5: Three month outlook for temperature and precipitation, December-February, 2010-11.

Colorado, where above normal snowfall is possible. Farther to the south across most of California, Nevada, New Mexico, Arizona, and southern and central Utah and Colorado, less precipitation and generally warmer conditions may be expected.

However, when a blocking upper ridge graces the Gulf of Alaska, as in the blue flow pattern illustrated in figure 4, the resulting north to northwesterly jet stream path brings cooler and drier weather to the Pacific Northwest as well as to Idaho, Wyoming, and Montana, with cold episodes reaching as far south as parts of California, Nevada, Utah, and Colorado.

During a La Niña winter the main jet stream may switch back and forth between these paths or favor one over another, so the outcome is never exactly the same. However, we can talk about the average behavior of the weather during La Niña. And interestingly, analysis has shown that La Niña, regardless of the strength of the anomaly, tends to be more consistent in the way it affects our weather than El Niño. That said, the average winter weather associated with a La Niña can vary significantly both between winters, during different parts of a winter, and between different regions during the same winter.

So what can we say about the mean weather during a La Niña winter? First, in the western United States the north/south dividing line between the increased and decreased precipitation seems to lie along a line roughly from San Francisco through central Nevada, central Utah to southeastern Wyoming. In La Niña, areas north of this line tend to have above-normal precipitation with south of the line at below-normal precipitation levels. In the region near the line, the outcome can go either way, but stronger La Niña events may favor increased precipitation farther south. Overall, the Cascades and the northern Rockies tend to have cooler, snowier and more active winters than normal. Southern Utah, southern Colorado, Arizona, and New Mexico tend toward drier and possibly warmer winters.

The vast size of Alaska can cause La Niña to have different effects in different regions. During a La Niña the upper ridge shown in Figure 4 is favored to lie between 170°W-150°W; however, its actual average position will change the mean temperatures for the winter. For example if the mean ridge axis falls near 160°W, the western parts of Alaska can be warmer than normal while eastern parts can be colder then normal. However, overall we can say that, on average, La Niña produces cooler and drier weather for the state.

Another characteristic of La Niña winters is a tendency for more meridianal (north-south) atmospheric circulation leading to more variations in the daily weather during the winter. When the warmer and wetter pattern illustrated in red in Figure 4 follows the cold pattern in blue, mountainous areas in the Pacific Northwest and eastward across the northern tier of the US into the northern Rockies can experience rapid temperature fluctuations that may result in dramatically rising avalanche danger: colder, lower-density snow or surface hoar followed by larger amounts of increasing density snowfall or rain. *(For more information regarding the relationship between ENSO and avalanche activity, see the sidebar below.)*

Hence, historically La Niña has typically produced an increased chance for above-normal precipitation and cooler-than-normal temperature to the north-central US westward with the strongest impact in the Pacific Northwest. This effect of La Niña is already apparent in the three-month outlooks for December through February issued by the National Weather Service *(see Figure 5)*.

Climate Change and La Niña

Before Washington and Oregon folks rejoice that abundant powder will soon be theirs for the taking, we need to consider research that indicates the overall affect of La Niña on the winter weather may be shifting due to climate change. As previously noted, there are indications that the impacts of ENSO events on global weather have altered since about 1970 due to climate change.

When La Niña observations are corrected for the slowly rising average temperatures (i.e., the trend in the mean is applied), researchers are finding that late-fall and early winter conditions may continue a slight bias toward cooler conditions, but this is increasingly confined to the Pacific Northwest. Across the remainder of the western US, normal or even warmer than normal conditions may occur *(see Figure 6 on page 21)*.

Similarly, changes in precipitation patterns have also been detected. The heaviest three-month average

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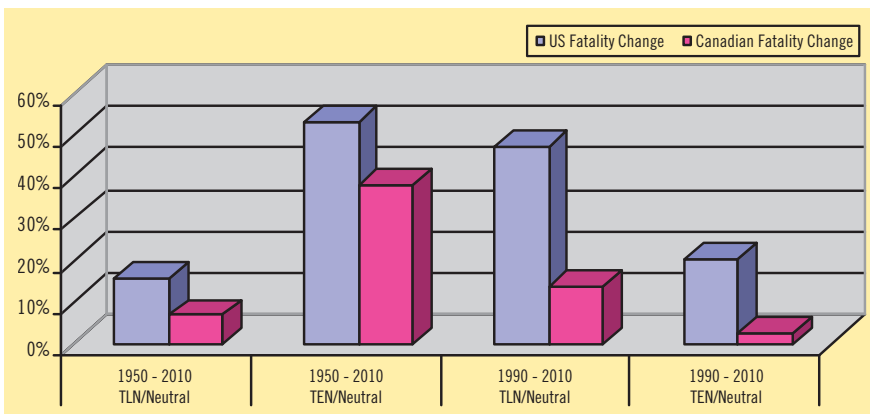
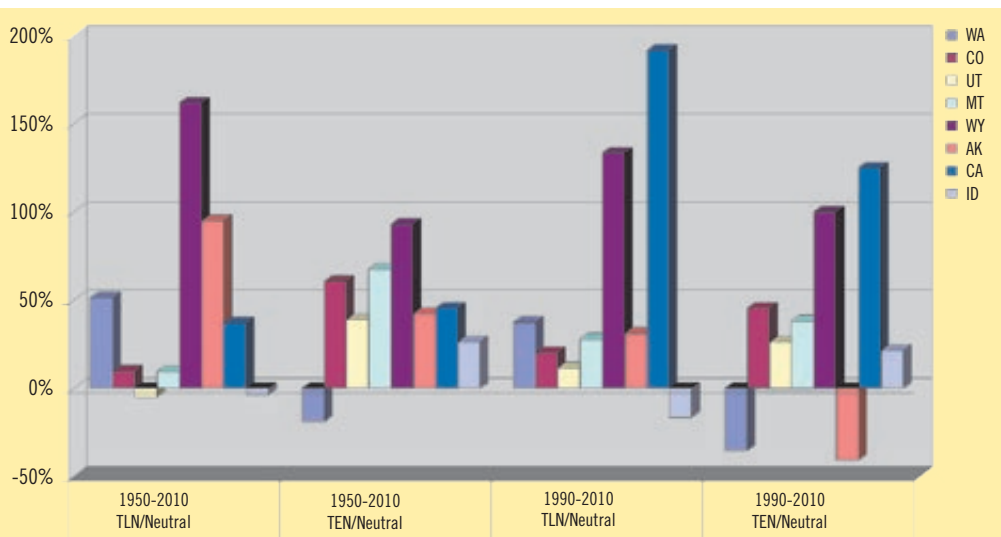


Percentage change in annual US and Canadian avalanche fatalities by ENSO event as compared to neutral years, 1950-2010 and 1990-2010 [TEN = total El Niño, TLN = total La Niña].



Percentage change in annual avalanche fatalities by state by ENSO event as compared to neutral years, 1950-2010 and 1990-2010 [TEN = total El Niño, TLN = total La Niña].

ENSO and Avalanches

Story by Mark Moore

As was initially indicated by an earlier study (Moore, 2008, *ENSO and Avalanche Fatalities in North America: Is There a Correlation?*; ISSW 2008 Proceedings), there may be a relationship between ENSO and avalanche fatalities in North America. The updated (through the winter of 2009/10) correlation figures *(see above)* relate the percentage change in annual fatalities between ENSO (El Niño and La Niña) and non-ENSO years for both the past 60 years (since 1950) and past 20 years (since 1990). While the state-by-state chart does show a decrease in fatalities for a few areas during La Niña winters (i.e., Idaho, Montana, and Utah), these are in the minority. In all other areas studied, including the US and Canada as a whole, the changes in annual fatalities range from subtle increases to rather significant ones.

Though the data is still too sparse to be statistically significant, even the possibility of such a correlation should set off cautionary flags for anyone venturing into the backcountry. Although you may know the typical snowpack that develops in your region quite well, this year's layering, bonding, depth, distribution, or some other critical aspect may develop differently than normal. Certainly the dataset suggests that something unique may be happening requiring you to update your experience skill set in order to safely enjoy the winter.

Indeed, as the following conclusion of the original correlation paper suggests, it is up to all of us to increase our awareness of the snowpack evolution in order to maximize our safe travel this winter:

…it appears that the character of the winter, the ensuing snowpack and its dangers, may be correlated with ENSO events. Over a winter this temporal and aerial danger distribution, especially if it results in unusual or unexpected snowpack evolution, may correlate to a higher number of fatalities, depending on the region and the time frame sampled. At the very least, knowledge that an ENSO-driven winter is imminent should trigger an increased awareness that deviations from a "normal" snowpack are possible, and that heightened awareness of such differences may be crucial to safe travel in snow-covered terrain.

Advances in Snowpack Weak Layer Tracking Using GIS

Story by Matthew Borish

[Eds: Figure 1 referred to in this article is the cover image.]

I clearly remember the first time

I read about the importance of knowing the location of buried surface hoar. The author stated mapping the surface hoar while it was still on the surface was the way to mitigate this problem. Unfortunately, no details were given on how to complete the mapping task. It's probably safe to assume I'm not the only one who has laid awake at night thinking about this conundrum. Relatively recently in the avalanche realm, a digital presence has jammed its foot in the door. There are probably still a few diehards that swear by their old Ortovox F1 analog beacons, but thankfully most of us have embraced technology's capacity to keep us a little safer in the mountains. Using a Geographic Information System (GIS) to map and monitor snowpack weak layers capitalizes upon today's powerful computing abilities by efficiently and accurately displaying dynamic intuitive outputs that can help us answer many of the most pressing questions we might have.

I'm one of the lucky people who gets to do exactly what I would choose to do if I could have any job in the world. Yes, you guessed it. I get paid to heli-ski in Alaska. Most days, it truly is the best job anyone could ever have. Some days though, as I found out several years ago when a report of an avalanche came over my radio, it can be the hardest job in the world. Not everyone is so fortunate to have a full helicopter load of guides out training for the day in the next drainage over when they get buried. Thankfully, the victim of this particular avalanche survived with little more than some bruising. In spite of this, I suspect it was a life-changing event for him. I know it was for me. It was a total wake-up call which catalyzed my desire to learn more about weak layer spatial variability…a lot more.

For the last two winter seasons, I've made it my task to explore surface hoar spatial distribution in the Chilkat and Takhinsha Mountains near Haines, Alaska as part of my master's thesis. I learned enough about GIS as an undergrad to know that it would be a fundamental part of my project. Why? Simply put, many of the traditional techniques of cataloging avalanche observations such as field books, lists, forms, or even digital snow profiles essentially lacked sufficient geographical components that could exponentially improve their worth. Sure, maybe someone wrote down the name of the bowl where they dug a snowpit or perhaps even logged the location with a GPS, but too often these words and numbers don't really do much to answer the things we need to know. What a GIS does is allow us to geographically visualize our observations and query

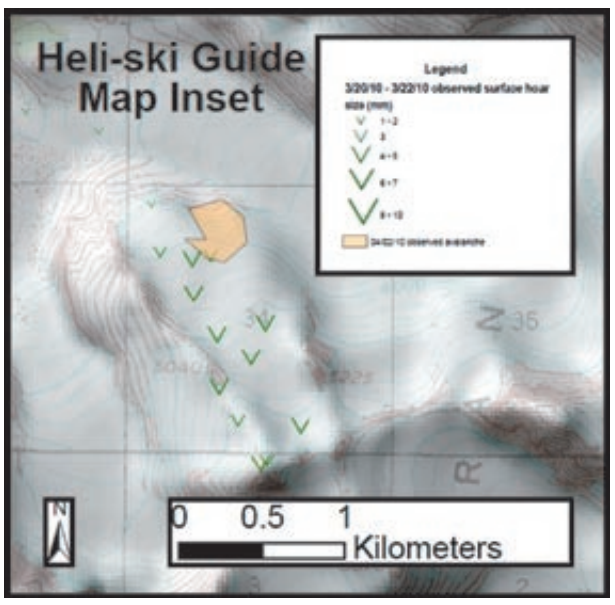


Figure 2. Thematic surface hoar and avalanche observation layers above 30m hillshade and USGS 1:63,360 topographic reference layers corresponding to the avalanche in Figure 1.

our data *(MacEachren et al., 1999)*. In other words, it lets us see the big picture.

One of the foundational components of a GIS is a layer. These can be anything from an aerial photo to a map of slope angles or aspects computed by a program. Layers can easily be moved around on top of or below each other and manipulated in GIS programs to suit user needs *(Longley et al., 2005)*. In most avalanche applications, a digital elevation model (DEM) is a good base layer. The resolution of DEMs varies, but newer DEMs produced with Light Detection and Ranging (LiDAR) are accurate to around a meter *(Hodgson et al., 2003)*. This allows the visualization of individual slope scale terrain features. While the high price tags of LiDAR-generated DEMs have thus far kept them from being widely distributed, costs are decreasing, and they are starting to make the rounds. Currently, many 10m and 30m DEMs are available as free downloads and are sufficient for monitoring snowpack weak layers at all but the finest scales.

Once reference layers are in place, users can add in thematic layers to gain insights into their particular situations. For my project in Alaska, I have several layers composed of surface hoar observations, snowpit data, and avalanche observations. It is a simple task to implement symbols in-line with the current standard avalanche observation guidelines in a GIS. While jet black might work for some, I chose to represent unburied surface hoar using the color green. Conversely, I picked red for my buried surface hoar observations. Layer symbols can also be manipulated to represent their actual sizes as well. This is nice in the avalanche world

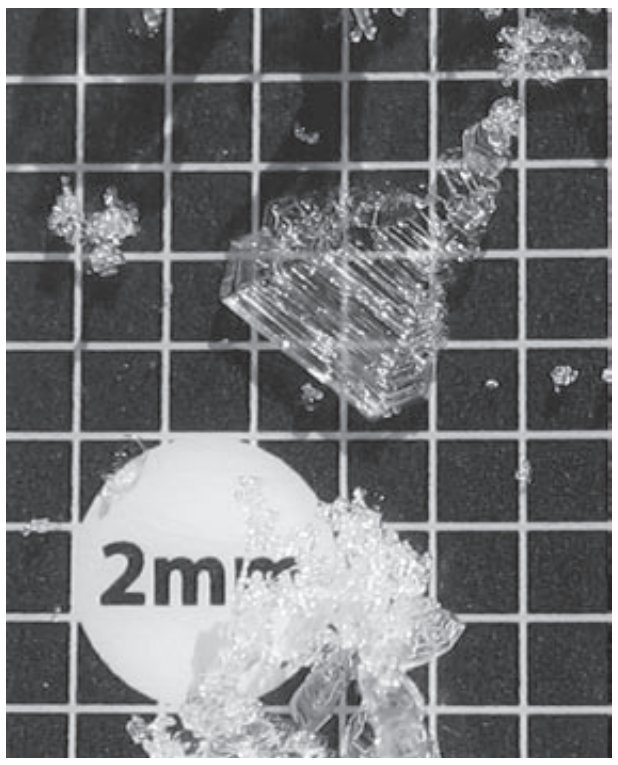
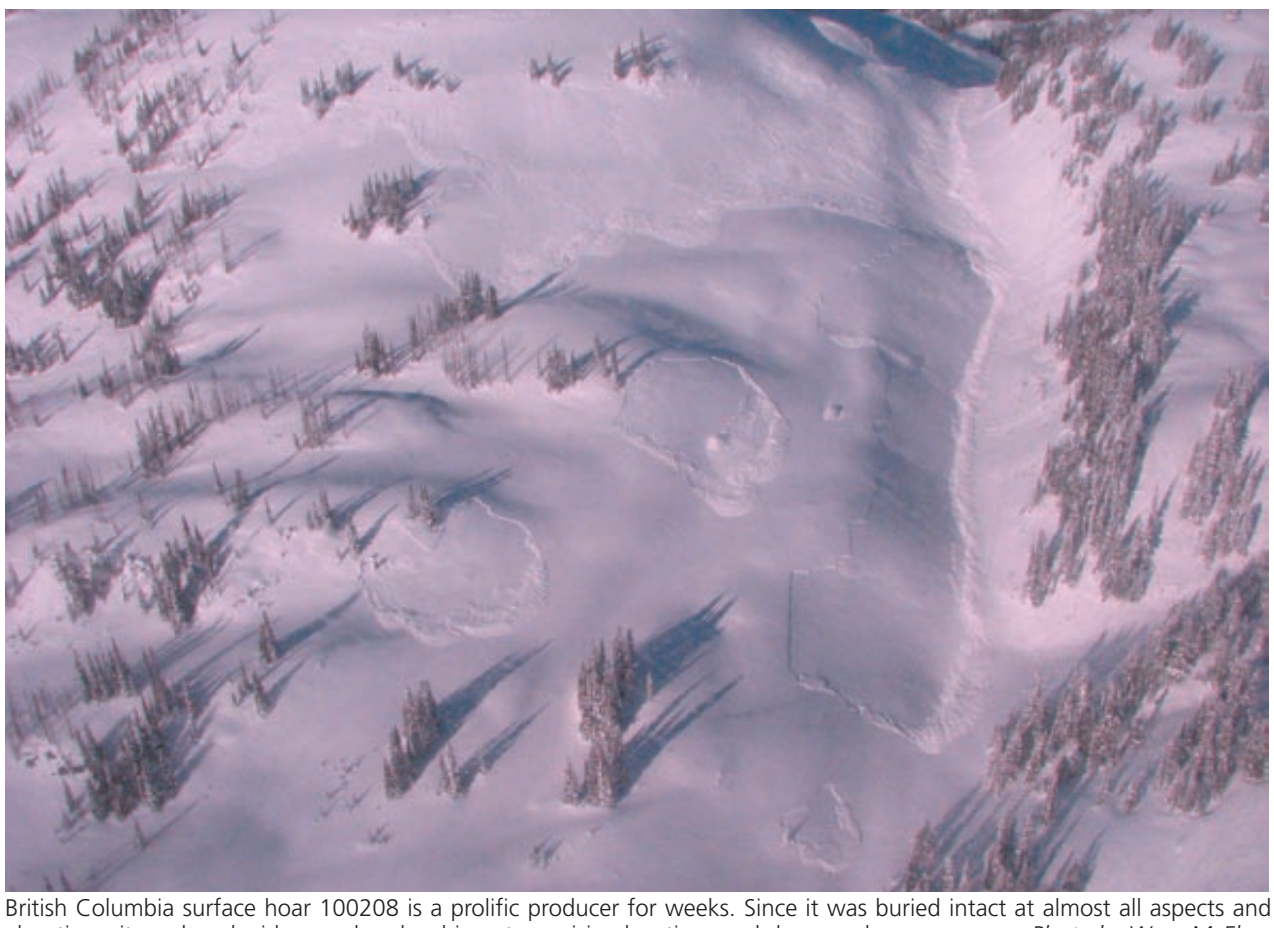


Figure 3. Surface hoar crystals photographed on March 21, 2010, near the April 2 avalanche.

since weak layer crystal size has been observed as inversely proportional to its strength *(Jamieson and Johnston, 1999)*. The beauty lies in the simplicity. Now instead of a list of runs where we saw surface hoar across our heli-skiing terrain or a traditional map with a bunch of marker scribbles all over it, we have a clean comprehensive dataset viewable on a large screen and printed outputs that guides can take into the field, both of which provide a ton information without a ton of wasted energy. After investing in these techniques, we didn't have to wait too long before receiving bountiful dividends *(Figures 1-3)*.

Taking it a step further, a GIS supplies the capacity to explore data in ways that might reveal trends that may otherwise be overlooked *(MacEachren et al. 1999)*. This process revolves around tables of data associated with each layer file mentioned above. Users can customize tables to store attributes about the entities they are interested in. For instance, with buried surface hoar layers, it makes sense to store information about observation coordinates, layer depth, layer thickness, and so on in columns with each observation composing a row. Some of the columns I keep for stability tests include ECT tap number, ECT propagation value, shear quality, etc. What sets this apart from keeping this same data in something such as a traditional spreadsheet is the way that we can sift through and manipulate it. Using structured query language (SQL) or a graphic



British Columbia surface hoar 100208 is a prolific producer for weeks. Since it was buried intact at almost all aspects and elevations, it produced widespread avalanching at surprising locations and slope angles. *Photo by Wren McElroy*

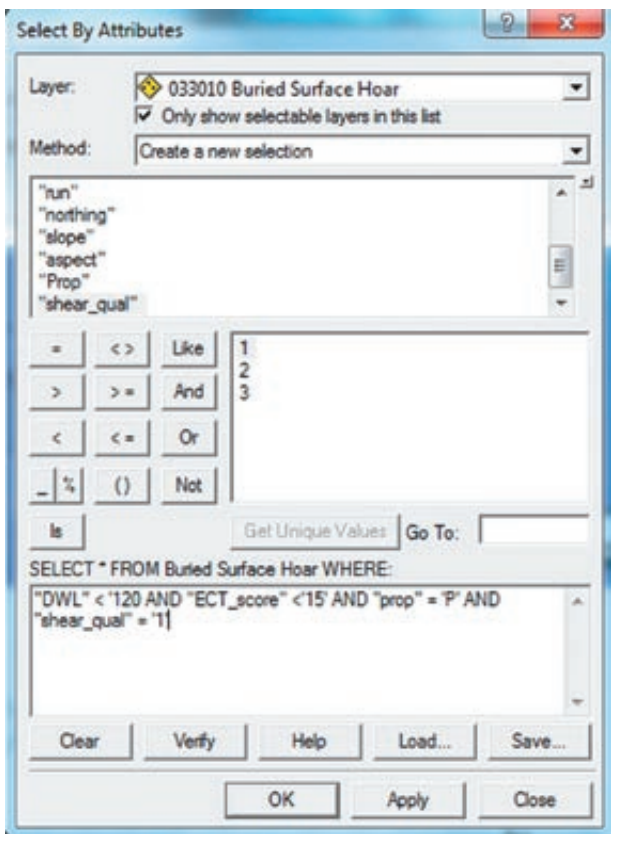


Figure 4. A simple hypothetical query requesting buried surface hoar observations with weak layer depths less than 120cm, ECT scores below 15 that propagated all the way across the column in ## or ##+1 taps with a shear quality of 1.

Attributes of 033010 Buried Surface Hoar

Date	DWL	WLT	ECT_score	prop	shear_qual	easting	northing	run	slope	aspect
33010	60	4	10	N	3	468849	6557427	Echo and the Bunnymen	42	10
33010	62	5	10	P	1	465149	6559356	Telemark West	35	87
33010	62	4	12	N	2	467808	6558094	Echo and the Bunnymen	40	10
33010	72	4	14	P	2	467001	6553869	Uncle Tom's Cabin	36	40
33010	56	3	17	N	2	468182	6560864	Haska Bowl	32	315

Record: Show: All Selected Records (1 out of 5 Selected) Options

Figure 5. Query results in table form. Icons meeting selection criteria are also highlighted on user maps.

user interface (GUI), it is a simple task to select data that we're most interested in.

Whether it makes sense to search through an entire season's data, or just information acquired regarding a specific weak layer, it's your choice. Let's just say for simplicity though, you would like to explore all of your buried surface hoar observations from a particular day. Maybe you're curious to know which of those observations had weak layer depths less than 120cm. Perhaps you would also like to see which of your stability tests produced Q1 ECTPs with fewer than 15 taps (Figure 4). In less time than it takes to put your ski boots on, you can see very detailed results from an information request in the form of highlighted rows in a table and symbols on a map *(Figure 5)*. Admittedly, for an average weekend warrior, this capability might be closer to the novelty side of the spectrum. However, for a commercial guiding outfit or a forecast center that deals with hundreds of observations a week, this aptitude is very exciting to say the least.

Another feature, which is a favorite of our guide team, is the hyperlink. This function pulls up image data for a specified point or area with a click of the mouse *(ESRI® 2009)*. Rather than relying on a narrative where someone witnessed an interesting event in the field the day before, in which the exact location can get lost in translation, we just click on the map and instantly produce a cataloged photo of the area. Be it a guide meeting or patrol briefing, at six in the morning every saved second is appreciated. Hyperlinks can also be implemented to show pit-data graphics for their associated icons on a map.

Hopefully, GIS is sounding pretty effective for tracking snowpack weak layers. The limits of a GIS are essentially a function of users' imaginations and go well beyond the scope of this article. Relatively user-friendly, GIS-software packages are commercially available on the order of about four figures, while open source GIS software is available free for those with stronger computer skills or thinner wallets. Dissemination of GIS data is also available through web servers which allow end-users to view GIS outputs through standard web browsers or programs such as Google Earth® with no additional costs *(Figure 6)*. I suspect this will be the conduit that most GIS data passes through on its way to snow lovers in the coming years.

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Matt Borish says that we already know the really important things about him from reading his article. Some of his study results are available online at www.fsavalanche.com/NAC/techPages/articles/10_ISSW_Borish.pdf. Contact him with feedback or questions: matt@skiseaba.com.

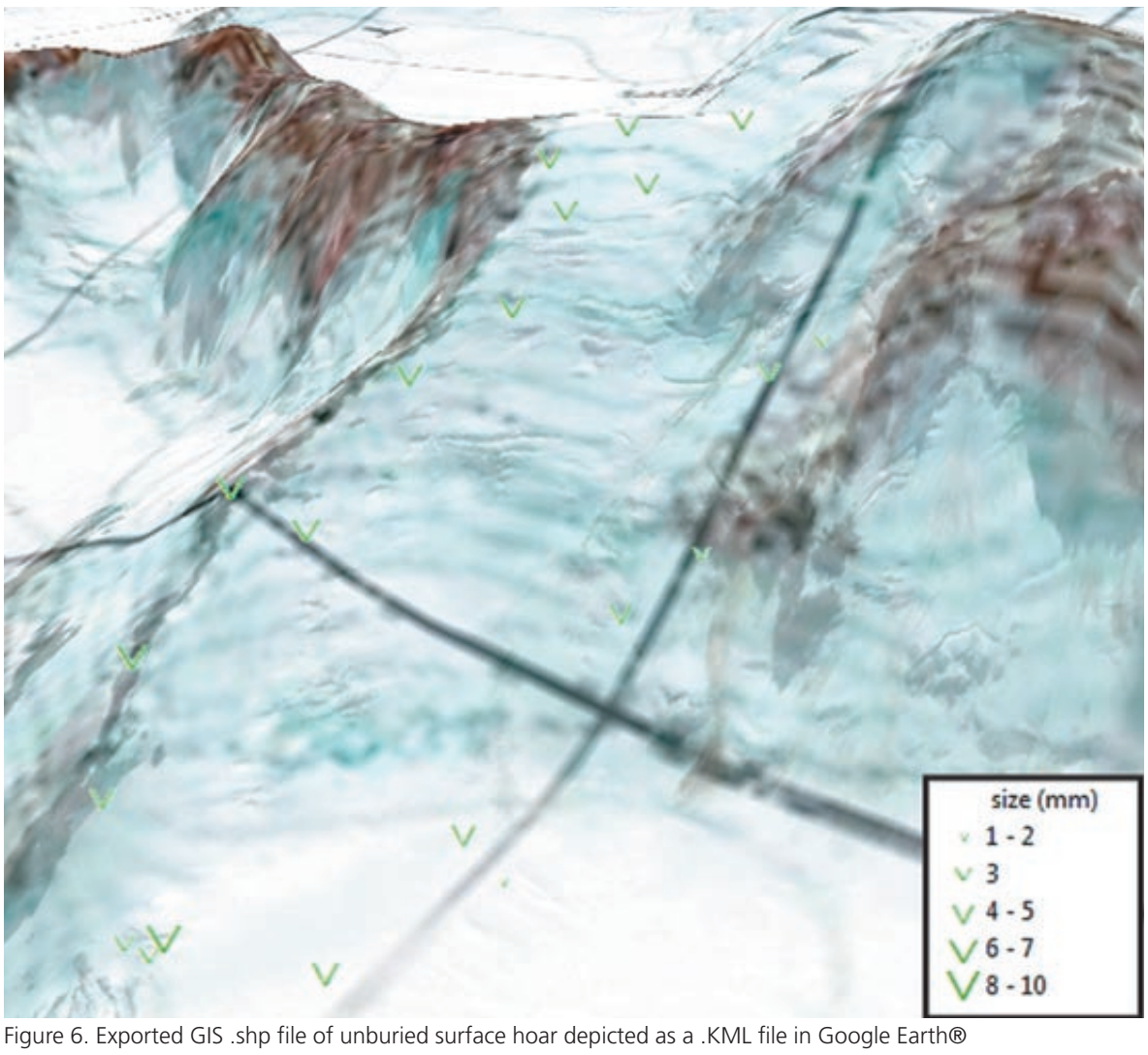


Figure 6. Exported GIS .shp file of unburied surface hoar depicted as a .KML file in Google Earth®

PLAYING BATTLESHIP

continued from cover

snowpack summary (among all those endless CT results), recorded as the surface form in the weather plot observations and seasonal time profile (if you have one). Perhaps you put a bright red line on the time profile when they are buried. But where exactly are they buried?

After the layer is buried, we cast about doing pinpoint sample-sized snow profiles, always with that niggling thought in the back of our mind: Is this truly a representative site? Hardly a thorough approach to tracking and communicating what is obviously a pretty big question, when it comes to risk management of these PWLs. I bet we can do better and I hope this gets some of those really smart people thinking of ways to do just this.

I suggest we start with the following simple changes: Better note taking that accounts for distribution, size, and terrain, and that accurately describes what we saw in the field. Maybe we should spend a bit more time on this and less time on non-critical temp and wind observations? It all has to start with field observations.

With this data, we can start mapping these daily observations on a large, small-scale map with a clear plastic overlay. This overlay allows you to draw observation boundaries, noting within that polygon the date, the observer, and the size and character of the crystals in a pen color specific to that layer. Once the surface hoar is hidden, this allows someone coming on shift a quick glance of some pretty useful info.

I had a situation this season where I had noted some isolated surface hoar at a ridge crest in early December. Later, another guide triggered that same isolated pocket and went for a ride. Yes, it had been noted during guides' meetings, etc., but that critical piece of surface hoar distribution was lost in the fog of time and the forest of info we thrash through on a regular basis. We need to go graphic on this one – the key being that it must be quick and easy to do, as we all have enough data to cope with already.

InfoEx summaries could also be more descriptive, or at least more accurately descriptive. My pet peeve is reading the usual: "Observed SH to 25mm." What the heck does that mean? Was that the stuff at the creek bottom pickup, was it widespread, was it isolated, if so where and why, and what percentage of the surface hoar is 25mm? We can do a way better job on that one too. How about something like this: "Observed isolated SH on N and NE aspects between 1800-1500m, 80% 2-3mm, 20% 10mm (limited to valley bottoms)."

This story first appeared in the publication Avalanche.ca, and is reproduced with permission of the CAC and Scott Davis.

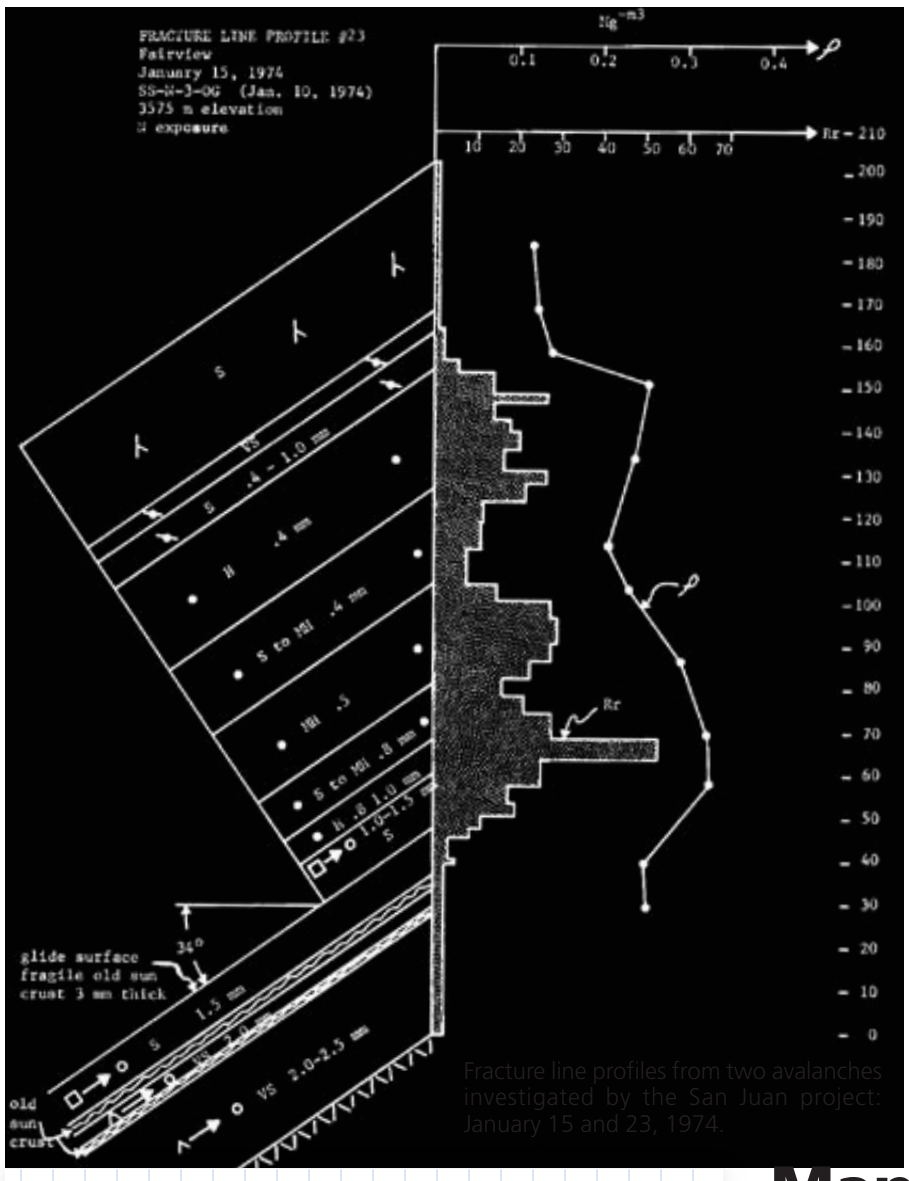
Scott Davis is an IFMGA/ACMG mountain guide and the former president of the Association of Canadian Mountain Guides. He writes, "33 years ago a 1950s vintage pickup truck gave me a lift home from my summer construction job at Spray Lakes. Steve Thomas was driving that truck (may he rest in peace), and after he finished regaling me with stories of Fred Schleiss and the Bostock Headwall, my destiny was set. I now call myself a proudly self-unemployed mountain guide who hangs his skis in Revy. Thanks Steve!"

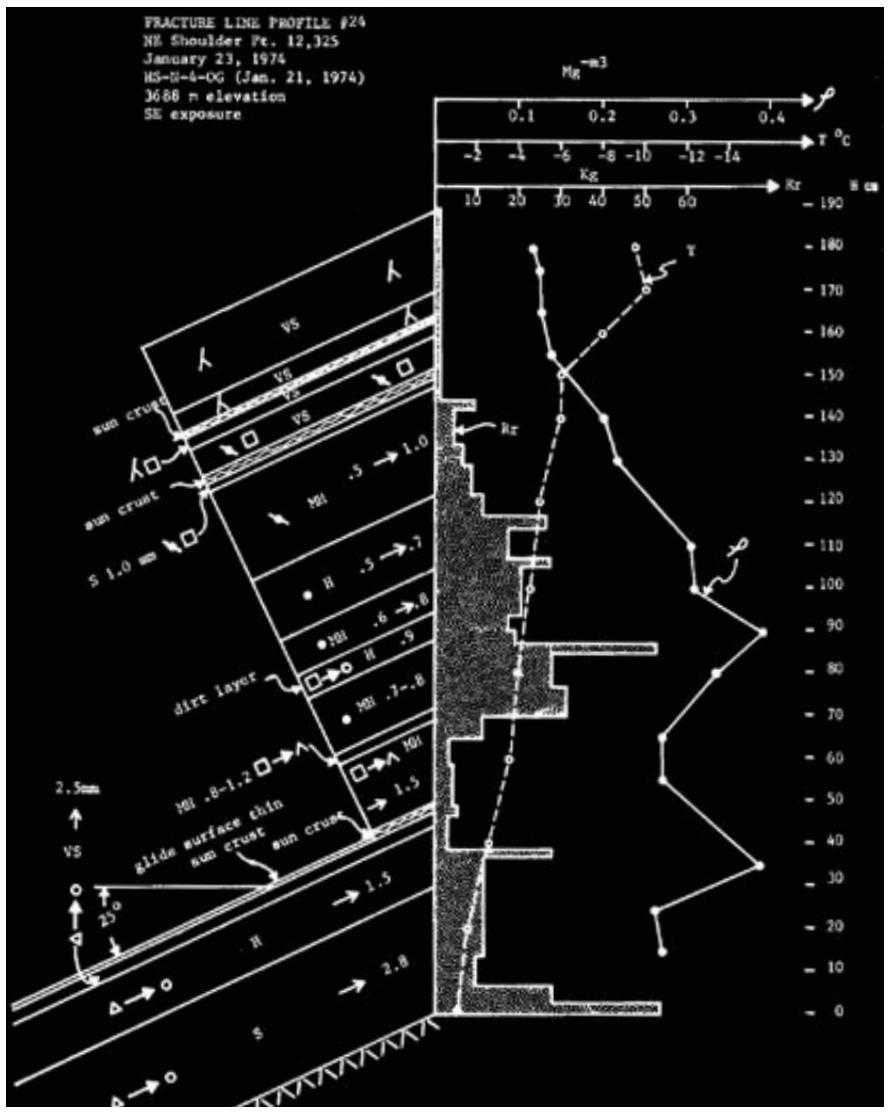
From Mike Best:

I think that doing accurate real-time mapping as Scott suggests is not very realistic in the field, however, I agree with him completely that information could be a little more specific as far as elevation, drainage, and so forth. I personally have had very good luck with elevational tracking in the Columbia Mountains - not sure how that would correlate with other ranges.

"The usual places" unfortunately works well for SH. I wish there were a better way to manage the hazard of this exceptionally dangerous, persistent, and weak layer, but I'm afraid that the only reliable way to travel recreationally when an active layer is present is to use terrain extremely conservatively. No amount of observation or mapping can safely guide choices in the field - the spatial variability of SH is simply too great, and the consequences too high, as the layer of concern reaches critical load. As Mark Klassen says, "When the question is stability, the answer is terrain."

Mike Best is a backcountry skier since 1990 who calls Bozeman his home, but spends far too much time skiing above buried and indeterminate SH layers in the Columbia Mountain.





Fracture line profiles from two avalanches investigated by the San Juan project: January 15 and 23, 1974.

From Ted Steiner:

As you know, our forecast area is pretty small – it covers about four lineal miles of rail, and if we go around the corner, six miles of highway. Anyway, all field observation (obs) days involve a start-zone elevation full profile. We hand enter all field obs/data into obs books then transcribe them into avi forecasts and into Snowpro (Gasman product). The Snowpro (SP) doc is then printed out and put up in our office for viewing, as well as saved in the cpx for future reference. We can also create PDFs of the SP profile and send as attachments to whomever wants to get nerdy.

Now, what I started on last year was creating a Google-based KML file with a GIS overlay of the forecast (fx) area. My hope is to create a dynamic, Web-based atlas of the fx area that can include historic and current obs/data related to avi, weather, and snowpack. Hence, start-zone profiles would be stored in the KML file and updated as needed. The information would then be available to all railway employees and management: 24/7 and across the country. No need for sending out emails all the time. And if someone is in an air-conditioned office in Fort Worth, Texas, wondering what the big deal is in lil Essex, Montana, they can just access the GoogleEarth-based KML file.

I was going to present a paper on this project at the ISSW in October, but I realized there are still some issues to be worked out that I did not feel comfortable publishing yet. Maybe next ISSW.

Ted Steiner is a BNSF Railway Avalanche Safety Consultant , Glacier, Montana and in the cover photo for TAR 29/1

From Scott Savage:

In SW Montana, early season weak layers are often associated with crusts or large wind events. When possible, we (Big Sky forecasters) photograph the crusts and post-wind-event snow surfaces. Once we start seeing avalanche activity on older layers, we can compare photos of avalanches to photos from earlier in the season, identifying on which layer the avalanche activity is occurring. If we have a good set of photos of the distribution of the weak layer/bed surface in question, we can determine where we have similar snowpack issues and act accordingly. When monitoring the distribution of near surface facets and other upper level weak layers later in the winter, we rely more on detailed notes and observations in our pit books.

Mapping Weak Layer Distributions

Story by Don Bachman

How do YOU map the distribution of a weak layer? Show me a page from your pit book, an overlay that is electronic or hand-drawn, a coherent narrative that is easy to interpret. Industry standard or personal innovation?

In response to the assignment above, I've submitted a couple of "historic" fracture line profiles contained in this publication. The San Juan Avalanche Project described in this publication was located in Silverton, Colorado.

Avalanche Release and Snow Characteristics; Final Report 1971 – 1975. Richard L. Armstrong and Jack D. Ives, Editors. Published May 1976 by the Institute of Arctic and Alpine Research, University of Colorado.

These profiles were taken using a ram penetrometer which was inserted into the snowpack above the fracture line, and systematically pounded into the snow by dropping a weight from a known distance along a guide bar until the ram is stopped by the ground. This instrument measures resistance to penetration and is depicted by the gray profile to the right of the snowpack structure diagram. The height of the snowpack (distance from ground up) is established and the device left in place as a reference for the snowpack stratigraphy analysis which is done from a pit dug to ground. The excavation is positioned so as to show the crown face and bed surface contact. Snow density is captured at roughly every 10cm and noted in Mg/-m3 units, and is depicted as a point-to-point line indicated by the Greek symbol _ (rho). Temperatures are taken on some pits using dial stem thermometers inserted into the pit wall.

The snowpack layers are delineated subjectively by using a stiff card (Visa, MC, or Medicare all work fine) or a spatula pulled down vertically while hardness of each layer is estimated by brushing the pit wall and inserting fist and fingers. The hardness scale was judged from very soft to very hard (vs – vh). Snow-grain types are identified with the help of a hand lens and measured on a grid card. Temperatures may be taken by inserting dial stem thermometers into the pit wall at every 10cm.

These fracture line profiles were accomplished by two observers; one would conduct the observation regimen while the other would take notes. The results would be drafted onto millimeter grid paper as soon as the team would return to the office in Silverton. Avalanche characteristics would be appended to the diagram indicating name, date, elevation, release characteristics, size and aspect.

Two examples of the 32 fracture-line profiles shown in the publication are reproduced. The total number of profiles done during the project were probably greater than 100, while over 2000 avalanche events, most of which released naturally in the absence of an external trigger, were observed and recorded by the research team during the four-year period.

Each of these profiles show surface layers of snow of relatively low density which offered little resistance to the penetrometer on the initial drop. Subsequent layers are stronger (offering greater resistance) until the strength (and corresponding density) was reduced by the presence of temperature gradient crystals. The weak layer coincides with a bed surface from which the avalanche released.

This information was a valuable component to the understanding of avalanche release and snow characteristics and aided in the project purpose for the study of the nature and causes of snow avalanches within the vicinity of Red Mountain Pass, Molas Pass, and Coal Bank Pass (US Highway 550) in the San Juan Mountains of Colorado.

The standard of this data collection protocol was based upon the Swiss methods developed at SLF Davos and the Cold Regions Research and Engineering Laboratory in Hanover, NH and brought to the project by Ed LaChapelle and Malcolm Mellor.

Don Bachman is a well-travelled avalanche professional who got his start in Colorado, on Berthoud Pass, A-Basin, and the San Juan Project, as referenced here. He was the AAA Executive Director for many years, and received the AAA Honorary Membership award in 2008. His current retired status allows him to be a prompt and dependable contributor and friend to The Avalanche Review.

An Argument for the Narrative

Story by Robby ReChord

I am not a scientist but I play one in the backcountry. This has been my opening line for my snowpack classes for the past few years, and while I am more familiar with snow science than Trapper John is with medicine, I represent the classic academic underachiever who found definition & passion in the mountains and has carved out a life showing others around them.

Scott Davis' "Battleship" metaphor resonated with me because of parallels I perceived with a rant I went on after I received critical feedback from my good friend and supervisor on the subject of my documentation from an eight-day trip I led last spring. The object of my ire was the avalanche rose (in addition to being academically challenged I have the penmanship of a 6-year old). I feel reluctant to document field observations in a rose because it reads to me as macro information when instead what I want to record is micro. I know information about the tour is included in the heading of the page but I would prefer to read- and thus record- in a narrative format, giving elevation, aspect and location to better describe pertinent information regarding weak layers and distribution. Perhaps this is due in part to the fact that evenings at The Snake River Brewery served as my introduction to sharing snow observations and avalanche education. I know there are legions of fans of the rose as a documentation tool and I am among them at certain times. At others though, as an auditory learner, I have felt like a square peg trying to fit in a round hole. I have to talk and think things through to get at the "so what" of the information recorded.

As I have pursued this line of thinking with my mentors and other educators I have been told to "do whatever works so long as the information is recorded." This does not sit well with me, so I'd like to put forth the idea that narrative format documentation should be taught and encouraged as a "gateway" to the rose. Part of this came from the work I did with Lynne last winter when I was "supervising" her on a professional level 2 course. We came up with a curriculum based on the seven problems model used by the UAC. Participants were asked to identify the primary and secondary problems of the day and what factors would cause these problems to stabilize or become more reactive. This model jived really well with my narrative style and helped focus my processing of information. In addition it helps all determine the question(s) of the day and we can match our test with the problem.

Back to my rant. A red flag went up when I was told that the weather observations on the one day of precipitation on the trip looked terrible; on a non-moving day I had five sets of weather obs but no info in the rose other than the snow surface conditions as the storm moved in. I had noted earlier that the snowpack was going isothermal and that my primary concerns were thaw instability or a new snow event. This set of observations represented the most pertinent notes of the trip, but they weren't in graphic form. Would my visually inclined supervisor have had a different take had I invested the time to submit notes in a narrative seven problems format versus using the rose?

So how does this relate to Scott's argument on management and documentation of PWLs? It's most important to me to know the trend in reactivity of a PWL. I can wade through pages of roses attempting to decipher other's notes or read a succinct paragraph. I want to put energy this coming season into making sure that those I teach and supervise (as well as myself) are accurately accounting for distribution, size, and terrain in their field notes and can tell the story of the snowpack beyond notations on a rose. I want them actively hypothesizing and testing their predictions. Additionally I will be a crusader for those who have a learning / communication style that lies more at the narrative end of the spectrum while not alienating those who prefer the graphic.

A final thought on Scott's closing line and "cheating a bit." A quick dictionary.com search for cheater only came up with negative connotations. My mind went to a breaker bar for lug nuts on a truck- a useful tool without which the job would be immeasurably more difficult. Go figure. I'll return to the back of the classroom now.

Robby ReChord is a program supervisor with The National Outdoor Leadership School in the Teton Valley, ID, where he proudly wears his "retro-grouch" badge. When not making telemark turns he can be found riding his rigid mountainbike or paddling an open canoe anywhere west of I-25. ❄

Look, Listen, and Feel

Story by Kent McBride

I map and track weak layers mostly with my memory and notes taken in my field book. I make myself paranoid of possible future slides once I've noticed that a weak layer has formed. This information is gathered by my senses with lots of looking, feeling, and listening. Being out in the mountains almost every day makes this easier than it sounds.

Feeling: I dig a ton of hasty pits with my hands, ski poles, shovel, and sometimes the tail of a ski. This helps me feel (tapping or pulling and pushing down on the snow) the weakness of the layer and the amount of energy it has when it releases. Also I use tons of pole tests if they're applicable.

Looking: Most of the time after a new load has been added on top of the weak layer of concern, I can scope the mountains and find fresh crowns and flanks on similar slopes (eg: steeper, higher, wind-loaded terrain). Also, I look at how reactive the weak layer is on micro features when I load them (small rollovers, pillows, above ski tracks, unsupported features, mini steeps).

Listening: By talking snow with everyone I run into and then digesting what they say about the weak layers. This motivates me to dig even more, because a lot of what you hear doesn't make any sense, but it helps me to look for layers I might have missed. And, of course, hearing any collapses while I'm out and about.

Kent McBride is a mountain guide from Jackson, Wyoming, who has been heli-ski guiding in Alaska since '96. With his recent IFGMA certification, he was able to spend last summer living the dream of climbing and guiding in Chamonix. He and his wife Penny are the proud parents of one-year-old Kachiro. ❄

From Jerry Hance:

The best way I know how to keep track of the unstable/stable layers is to be out there pushing and skiing on it every day. I do not consider unstable snow the "enemy" as much as it has a side to it that is not always so kind if you put yourself in the "wrong place at the wrong time."

Keeping track of the unstable layers and all layers means pushing, feeling, and skiing on it every day from the very start of the season to the end. All the layers deserve the same respect and attention regardless if they are unstable or not. If I miss a day, I feel somewhat lost and out of my touch with it, as it is constantly changing. The changes that occur overnight are often enough to lose the touch and feel of it, requiring a new assessment - or at least taking a few steps back in one's appraisal.

For me, unstable snow does not mean stay on the lower angles or stay at home today. Unstable snow actually gives you something to work with, a beginning.

The "stay on the lower-angle slopes on avalanche-prone days" rule of thumb has never worked for me. How can I feel the layers if I am only on the lower angles where there is no movement and quite frequently not even the same layers? Digging a pit on lower-angle slopes and finding an unstable layer there is just scare tactics. Once scared do you know anyone who is capable of good decision-making? I need to go to the steeps and get something moving and get the feel of the movement: touch it, feel it, and ski it. When I get something moving, I am opening the first page in a great book. Restricting oneself to lower-angle slopes is for me putting myself in the "wrong place at the wrong time."

Staying at home is another example of "wrong place at the wrong time." I like to get something to move and then work off that. When I am on the top of a ridge or peak, I feel very fortunate to get the steepest path or any path to slide. This creates that "beginning," learning something real. It is nice to obtain input from other sources, but the problem with making your decisions based on what you hear from others is that the snow is changing, and whatever you have heard may or may not be the actual situation when you get to wherever you are going.

Lynne's question was, "How do I keep track of the unstable layers in the snowpack throughout the year?" My short answer is, "By going out there and dancing and playing with it, the unstable/stable layers are easily kept track of.

During our discussion in October, someone added that after triggering a slide, maybe the surrounding slope is then considered stable, as it did not run with the other slide. That is a giant "maybe." I do not feel that way about the adjacent slopes; it is more about possibly creating a safety spot or zone if adjacent slope would release while I or someone else is on it. Not every slide creates a safety spot or zone; it obviously depends on the cleaned out slide path and other pertinent paths. However, as stated before, it is a beginning, and from there your management of the future moments becomes very critical.

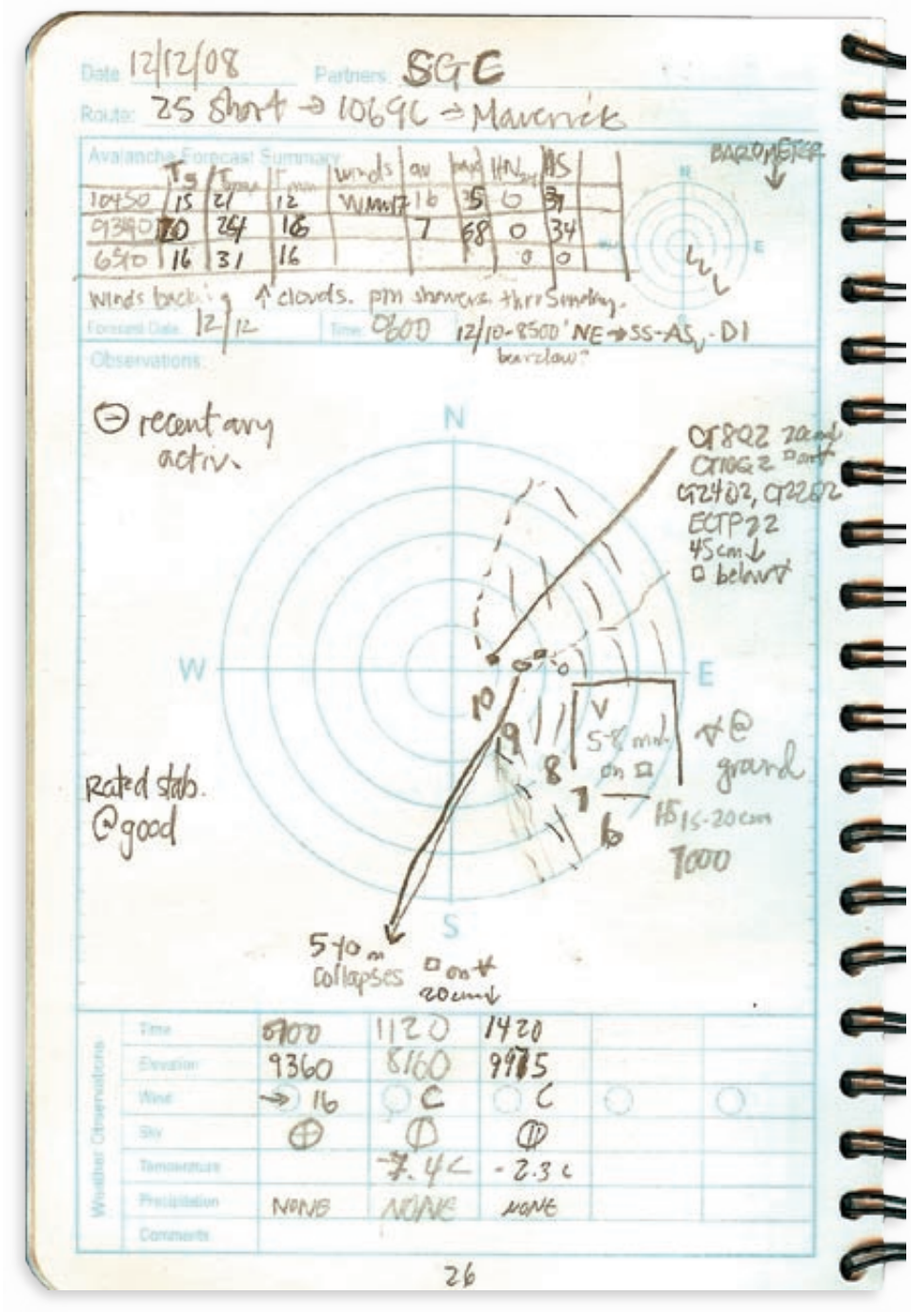
"As soon as you think you know something about the snowpack stability, you have made your first mistake."

Jerry has been heliski guiding in Valdez, Alaska, for 20 years and in Chile for the past two years, and the owner of JerrysHeliSkiAlaska.com for 15 years. He's a certified instructor for the American Avalanche Association and has taught hundreds of classes. He also claims to have made many "first mistakes." ❄

McBride feels that KerPlunk is similar to the game of Battleship for incomplete weak layer tracking:

KerPlunk is a game first marketed by the Ideal Toy Company in 1967. It consists of a plastic tube, a number of plastic rods called straws, and a number of marbles. The plastic tube stands upright on a base that contains four separate trays. The straws are passed through holes in the side of the tube to form a "web." The marbles are then placed in the top of the tube and held in place by the web.

At the start of play, the entire tube is rotated so that a hole in the base of the tube is aligned with the active player's tray. Players take turns removing a single straw from the cylinder while trying to minimize the number of marbles that fall through the tube and into their tray. Once a player has committed himself to a particular straw by touching it, they must remove it. The player who accumulates the fewest dropped marbles wins.



A page from one of Sarah Carpenter's field books.

Dancing with the Dragon

Story by Sarah Carpenter

The question that I am always wanting to answer is, "What dragon am I dancing with today?" During the last two years in the Tetons, I've danced with more dragons than I would have liked to: the pond-ice layer of 2008/09, which then turned into the double crust/facet sandwich of 2008/09, the depth hoar of 2009/10, the January 7 surface hoar layer, the January 28 surface hoar layer – to name just a few.

How do I track weak layers? I track the daily snow, weather, and avalanche observations on a spreadsheet (built by Ian McCammon). I also track these observations in my field book, which I carry with me every day. This allows me to constantly look back on the past weather data, as well as the previous day's snowpack observations.

During the winter of 2008/09, we had several remarkable avalanche cycles in and around Jackson Hole Mountain Resort. Our goal was to track where – in the out-of-bounds terrain that we were guiding – the crust sandwich had been cleaned out and where it still existed. We blew up a photograph of our terrain and drew in avalanches that had run below the pond-ice layer. We updated this photograph as it was necessary. This visual representation of the avalanche activity of our winter was a tremendous help for me in tracking a weak layer. That winter, I was able to assess which dragon I would likely be dancing with before I even left the guide office.

Sarah Carpenter is an owner of the American Avalanche Institute and co-chair of the AAA education committee. She works as a ski guide at Jackson Hole Mountain Resort and teaches many upper-level avalanche courses where she likes to know what kind of dragon she is hunting.

From Doug Chabot:

At the GNFAC we keep close tabs on weak layer distribution through narration: both verbally to each other and written in our snowpits, notes, and advisories. We do not physically create a map of the distribution. Since we are a small team of three who get in the field with each other regularly, we're able to informally talk to each other about the questionable layer. Every day our findings get written down in an office notebook and the "message" about the weak layer gets passed along first hand to each other. I realize this is a luxury given our small center. If there were more people involved it would be difficult to explain the distribution without the aid of an actual map. Because our advisories rely heavily on a narrative, we take the time to explain the distribution in every one. So far so good. This method seems to work for us and the public.

Doug Chabot is director of the Gallatin National Forest Avalanche Center. He is always willing to respond to random queries on marginally work-related topics.

LA NIÑA

continued from page 15

precipitation (November through January) seems to be shifting southward into Oregon and northern California and extending across the Intermountain West, rather than mainly spreading along the coast from northern California through Washington as in the past *(see Figure 7)*. In fact, for the coming winter, some Colorado forecasters are predicting periods of moderate to heavy snowfall west of the Continental Divide (especially in the north) with periods of abnormally warm, windy, and dry weather east of the Divide.

Summary

So, in the end what does all of this say about the upcoming winter season? Well, as any good long-range forecaster will tell you, "It depends." It depends on how the current La Niña evolves. It depends on how closely this winter follows the statistical averages of previous La Niñas and how much climate change affects the mix. It depends on which months you're talking about, because it is almost a certainty that some weeks or days during these upcoming months you will be cursing or praising all of these long-range predictions. So, however the winter of 2010/11 really does evolve, it comes down to this…enjoy every day as much as possible, make safety a concern every time you venture into avalanche terrain, and know that the weather (and snowpack) is developing exactly as it should!

Mark is a meteorologist and director of the Northwest Weather and Avalanche Center in Seattle, WA. Forecasts and field work in this decidedly maritime climate allow him to explore the complexities of both facets and crusts that coexist within this early Ensocene epoch of the slowly warming Avalearn era in the Pacific NW. Fortunately there remains an abundance of knowledge to be discovered and shared to help mitigate negative avalanche involvement outcomes within users embracing a constantly expanding risk band of snow activities.

Rich Marriott began his snow career studying glaciology at UW under Ed LaChapelle. Rich was also a founder of the NWAC and one of its first avalanche forecasters. Rich is the keeper of both the Avalanche Wiener and precious bottles of Sue Ferguson's The Avalanche Review *wine, which he doles out at ISSWs. In addition, he is currently Seattle's KING-5 TV meteorologist.* ❄

CAVEMAN METEOROLOGY:

La Niña, El Niño, Nada Niño

Story by Jim Woodmencey

I call it "caveman meteorology." Most skiers practice it, as do some avalanche professionals. By mid-August every year you begin to hear the first utterances, coming in the form of brief grunting sounds, when the question is first raised, "What kind of a winter are we going to have?"

The short answers are: "Ughh, it's El Niño," or, "Unhh, it's La Niña."

These primeval phrases have been translated over time to mean that we will have either a dismal or bountiful season of powder skiing.

How the winter's weather actually shakes out is dependent on a lot of things, meteorologically speaking. I find it worrisome when people jump on the caveman bandwagon and resign themselves to the idea that El Niño means "no snow" and La Niña means "big dumps," at least in the Pacific Northwest and northern Rockies.

In this age of advanced atmospheric modeling – with a constantly evolving climate change conundrum that adds even more complexity to the situation – I would hope for a more comprehensive answer to this popular pre-season question. However, it seems to have become the norm to revert to the way of the Neanderthal, grunting out a few syllables to explain the entire winter's upcoming weather.

Skiers and snowboarders where I live in Jackson Hole are already wringing their hands in anticipation of a HUGE winter. Because, "It's a La Niña year!" Not like last year, when snowfall was meager well into December. Because that was an El Niño year, of course.

Bottom-line is, caveman meteorology bases what you know on your past experience along with some statistics. That is, there has been a higher occurrence of above normal snowfall winters during La Niña conditions than during El Niño conditions.

In Jackson Hole, La Niña winters have produced above-normal snowfall winters about 70% of the time. El Niño winters have had about a 50-50 chance of being an above-normal snowfall winter. And the years when ENSO conditions were considered neutral throughout the winter months, only 30% of those had above-normal snowfall totals at the end of the season. This is what I call a "No Niño" condition, or maybe more correctly, "Nada Niño." That is the Niño to really grunt about in Jackson Hole.

The first snowfall of the season was big in the Tetons – on October 25 and 26, 2010 – thus confirming the local skier's belief that, "La Niña, good. El Niño bad."

They are a greedy lot, skiers and snowboarders, and if the snowstorms do not continue to come on a regular basis, they will start making guttural comments, "Ugh, where La Niña?"

I've considered fashioning my daily weather forecasts in this caveman style and simply state either, "Unh, snow today," or, "Ugh, no snow today." And just forget about all the possibilities in-between. That's all they wanted to know anyhow.

Jim Woodmencey is a meteorologist in Jackson, WY. Jim is the author of the book Reading Weather, *a retired heli-ski guide, and he recently wrote the content for COMET's online learning module: Avalanche Weather Forecasting.* ❄

TEMPERATURE DEPARTURES (°C) FOR RANGES OF THE OCEANIC NIÑO INDEX (ONI) DURING NOVEMBER-JANUARY

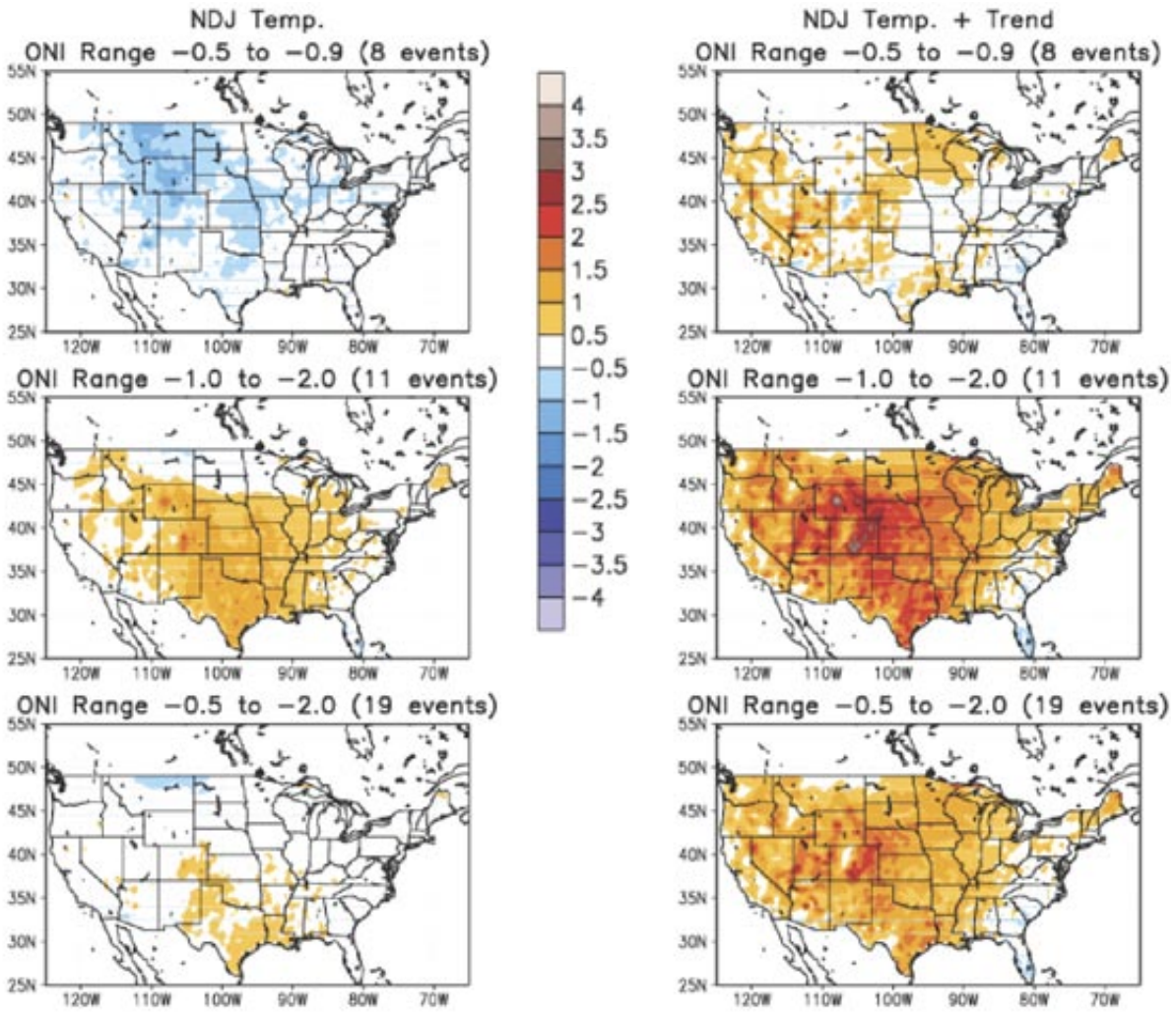


Figure 6: Temperature departures from normal for La Niña winters against a constant normal (left column) and against a normal adjusted for measured temperature trends (right column).

PRECIPITATION DEPARTURES (MM) FOR RANGES OF THE OCEANIC NIÑO INDEX (ONI) DURING NOVEMBER-JANUARY

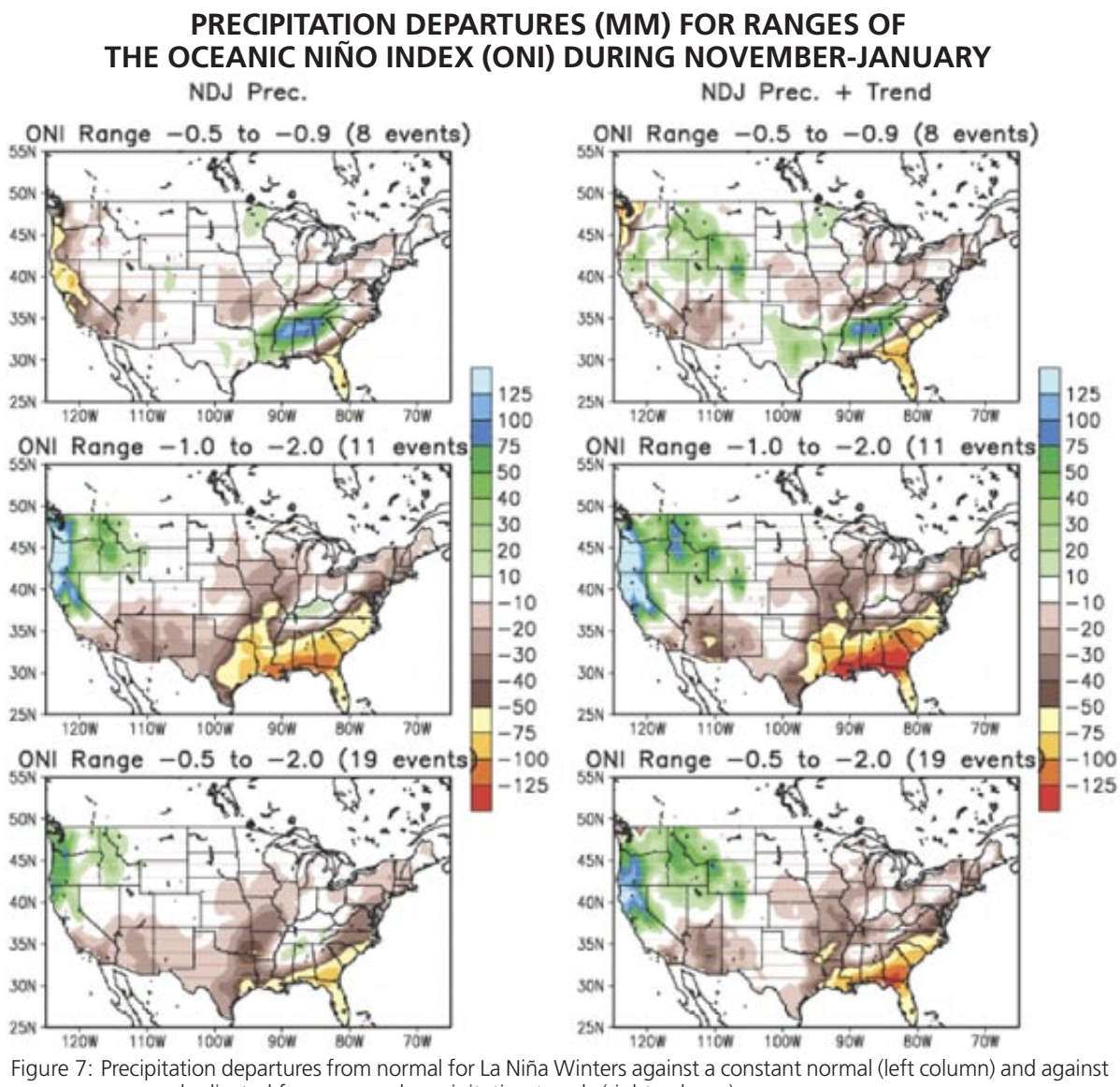


Figure 7: Precipitation departures from normal for La Niña Winters against a constant normal (left column) and against a normal adjusted for measured precipitation trends (right column).

crown profiles

I'll have mine shaken, not loaded.

Earthquake-Induced Avalanching in Canterbury, New Zealand

Story by Jordy Hendrikx, Andrew Hobman, Karl Birkeland

Figure 5: Skiers make tracks between two earthquake-triggered avalanches on a southeast aspect in the Palmer Range, New Zealand. *Photo by L. Adams, Methven HeliSki*

A magnitude 7.1 earthquake occurred at 4:35am (New Zealand Time) on September 4, 2010. With an epicenter just 40km west of Christchurch city (43.55°S, 172.18°E) and a focal depth of only 10km *(Figure 1)*, the earthquake was widely felt through the entire South Island and the lower half of the North Island of New Zealand. Within the Canterbury region shaking intensities of 6 to 7 were widely felt, with a maximum shaking intensity 9 on the New Zealand Modified Mercalli Intensity Scale *(Figure 2)*. This earthquake is the most damaging earthquake in New Zealand since the 1931 Hawke's Bay earthquake, but there was fortunately no loss of life despite the extensive building damage *(Figure 3)*.

While much of the urban areas in Canterbury suffered damage to buildings, liquefaction, broken water and sewerage mains, and disruption to power supplies, it is the impact on the alpine areas and the snowpack in particular that this article will consider. It has long been known that avalanches can be induced by large seismic triggers with the May 1970 M7.8 in Peru and the March 1964 M9.2 in Alaska just a couple of the more notable events *(See Podolskiy et al., 2010 for a good review)*. With Canterbury in the middle of the Southern Hemisphere winter it was therefore not surprising to hear that this M7.1 had caused avalanche activity.

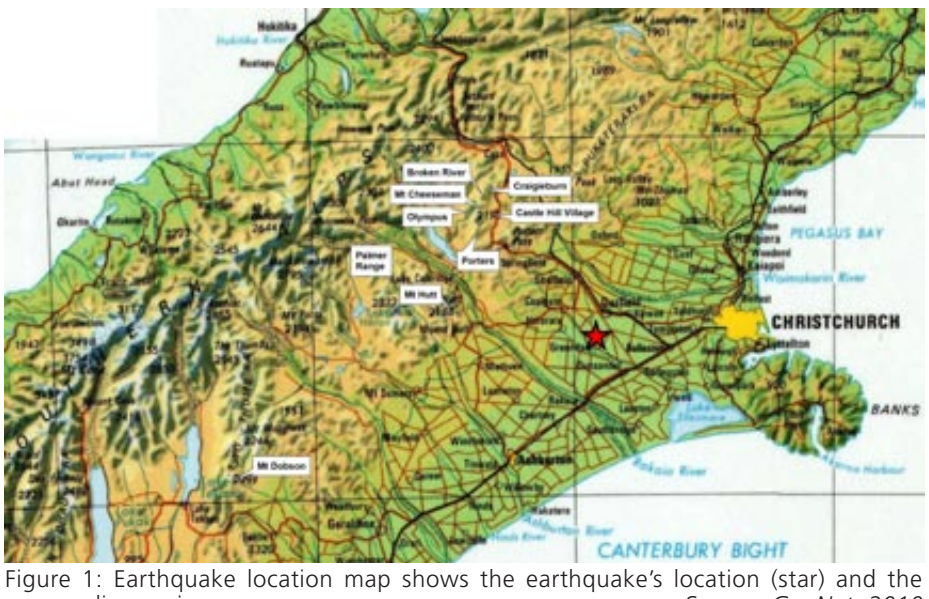


Figure 1: Earthquake location map shows the earthquake's location (star) and the surrounding region. *Source: GeoNet, 2010*

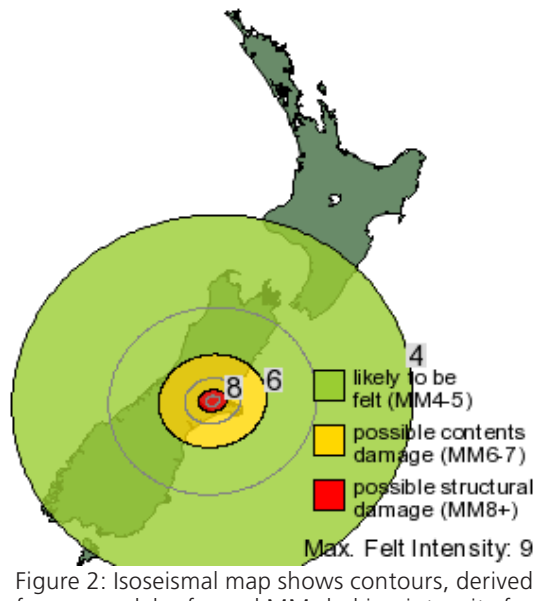


Figure 2: Isoseismal map shows contours, derived from a model, of equal MM shaking intensity for the earthquake. *Source: GeoNet, 2010*

Earthquake Data

The earthquake was widely felt through the entire South Island and the lower half of the North Island of New Zealand with maximum felt intensities of MM9. The observed shaking intensity was documented using the Modified Mercalli (MM) scale. Used in New Zealand, this scale has a 12-step ranking (opposed to 10), with 1 representing the weakest of shaking and 12 representing almost complete destruction.

The motion of the ground was also recorded by a series of instruments that document the movement in terms of ground displacement, velocity and acceleration. These instruments are located throughout Canterbury *(Figure 1)*, but we will look at the sites nearest the main alpine regions namely; Arthur's Pass, Castle Hill Village (inland from Springfield), Oxford and finally Christchurch.

Figure 3: Earthquake damage in central Christchurch. *Photo by C Cross*

The Peak Ground Acceleration (PGA) that was measured at each of the recoding stations is measured in units of percent-g (%g), where g is the acceleration due to the force of gravity (i.e. 9.8 m/s2). Values of 8%g to almost 30%g were recorded at Arthurs Pass to Christchurch *(Table 1)*. In studies of building damage a PGA value of 20%g is often used to define the lower damage limit, but recent work also shows substantial damage can occur to buildings at lower PGA values of 10-20%g *(e.g. Lee et al., 2003)*.The pattern of PGA can be quite complicated at smaller scales, showing variability over a few kilometers. This can be mostly explained by the differing soil types and topography near the stations that can significantly change the characteristics of the seismic waves. This small-scale variability will influence how PGA is experienced in the mountains.

The Peak Ground Velocity (PGV) was also measured at each of the recoding stations, measured in units of centimeters per second (cm/s). Values of about 4cm/s to over 30cm/s were recorded at Arthurs Pass to Christchurch *(Table 1)*. In studies of building damage there is a strong relation with increasing PGV, with considerable damage when the PGV exceeds 30cm/s *(Lee et al., 2003)*. Both PGA and PGV give a good correlation with reported shaking

Table 1: Earthquake recorders (see Figure 1 on previous page for locations). *Source: GeoNet, 2010*

Location	MM	Shaking instruments	
		PGA	PGV
Methven	4-7	-	-
Arthurs Pass	4	7.98 %g	4.08 cm/s
Castle Hill village	5	11.44 %g	10.52 cm/s
Lake Coleridge	5-6	-	-
Oxford	4-7	15.47 %g	9.88 cm/s
Christchurch	4-8	29.70 %g* 27.76 %g#	14.82 cm/s* 32.13 cm/s#

*Christchurch Aero Club #Papanui High School (both locations within Christchurch)

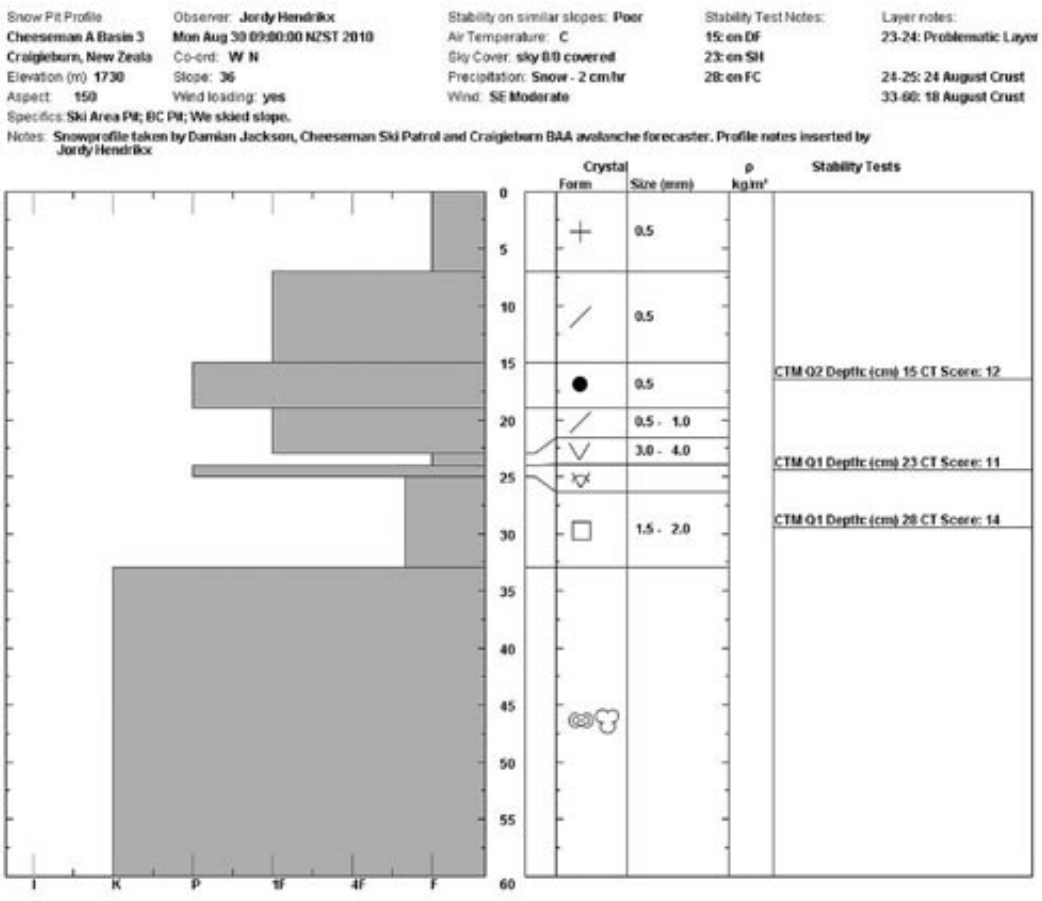


Figure 4: Snow profile in A Basin at Mt Cheeseman Skifield, Craigieburn Range *Source: D. Jackson*

for earthquakes larger than magnitude 5 and above *(GeoNet., 2010)*.

Snow Stability Prior to the Quake

In New Zealand the Mountain Safety Council (MSC) are responsible for daily public avalanche advisories for the key alpine regions *(see www.avalanche.net.nz)*. The two main regions impacted by this earthquake were the Craigieburn Range and Mt Hutt/Arrowsmiths Region. The forecasts for these are produced by assimilating data from a number of contributors and sources. The backcountry avalanche advisories on September 3 for the Craigieburn Range and for Mt Hutt/Arrowsmiths region were reporting a Considerable danger rating, according to the 5-step avalanche danger scale.

In the Craigieburn Range the forecaster noted that the snow was strong at depth on the northern half but remained weak on slopes facing SW-E with a host of persistent-type weaknesses (surface hoar, facets) having been buried by the past weeks accumulations (50cm or so with thicker wind deposits). They noted that the slopes with the persistent weak layer (SW-E) "…remain tender in areas and lack only a trigger."

In general, in the days preceding September 4, both of these regions were experiencing new snow and strong westerly winds. Reports of slab development on easterly facing slopes above 1600m of around 50-100cm were not uncommon. In the Mt Hutt/Arrowsmiths region a cycle of natural avalanche activity was anticipated. The forecasters had noted a surface hoar layer that might have been buried intact on certain aspects, but the main concern was the new snow and the wind loading, and only the deeper buried layers on particular aspects. Explosive control and ski cutting in the Craigieburn Range on the third had generally resulted in very limited activity on eastern half slopes. Reported snow-stability tests included a CTM14 RP down 5cm within low-density storm snow. The buried facets and surface hour (where present) had not been reported to show any sign of activity but was still of some concern.

Despite this new snow and strong wind loading, snowpack-stability assessments in these regions at elevations from 1500m to 2000m had generally improved from Fair-to-Poor on the second, to Good-to-Fair on the third. This was mainly because the bonding of the new storm snow was considered to be relatively strong, and the slabs had been mostly unresponsive in testing. The weaknesses deeper in the snowpack, such as the lower faceted layer, the crust, and the buried surface hoar were still a concern on a few aspects. While this layer had been unresponsive so far, the forecasters knew that the surface hoar layer (where buried) and faceted layer were both 5-out-of-5 scores on the lemon count for snow structure factors *(McCammon and Schweizer, 2002)*. A snow profile taken on August 30 (four days before the earthquake) shows the facets, crust, and surface hoar, but the new (and subsequent) wind loading is noted as the primary concern *(Figure 4)*. Further additional new snow load was added to this snowpack in the subsequent four days.

By the end of September 3, most locations were reporting the arrival of another westerly system with new snowfall and strong winds from the NW to W. In the Mt Hutt region soft-slab development with at least 40cm HST on sheltered slopes was reported by late afternoon of the third. Data from a remote climate station in the Mt Hutt/

Continued on next page ➡

The west face of Porters ski area, which is out of bounds, slid during the New Zealand earthquake event this September. *Photo by Brad Carpenter*

Earthquake-Caused Avalanches: New Zealand

Story by Brad Carpenter

On September 4, 2010, a magnitude 7.1 earthquake shook the Canterbury region of New Zealand. The epicenter of the earthquake was located approximately 50km from Porters ski area, where I have worked as a ski patroller for three seasons, and 40km from downtown Christchurch, a city of 386,000 people.

Porters is located at the southern end of the Craigieburn Range, a 28km long SE-NW running ridge of mountains averaging around 2000m in elevation at the highest and dropping to around 700m at valley floor. Besides Porters there are three other ski areas located in the Craigieburn Range: Mt Cheeseman, Broken River, and Craigieburn ski areas.

The earthquake struck at what was probably the most opportune time, 0430. At Porters, ski patrol stays in the employee housing building known as the Longframe, a triple-long, double-wide trailer, located at approximately 900m elevation and a quick five-minute drive to the base area. Everybody in the Longframe was asleep when the quake hit, and the only people on the mountain were one groomer driver and the road grader driver. The shaking started out slow and then grew in ferocity until the entire Longframe building was creaking and moaning; this lasted for over a minute. I remember holding onto my bed thinking it might be a good time to run for the closet when finally the tremors subsided and normalcy returned.

After ensuring the staff on the hill were safe, the snow safety director, Simon Morris, and I came up with our response plan to make sure all the staff buildings and the rest of the staff were okay, then work our way up the mountain to see what had occurred with the snowpack.

At first light it became very apparent that, at least inbounds, nothing had occurred. We could observe no new naturals, no signs of any instabilities, no visible cracking or collapsing. As we made our way higher on the mountain the same held true, but then at the top of the final T-bar lift, where the backcountry comes into full view, the extent of the earthquake became more apparent. Numerous size 2 to size 3 avalanches were visible along most ridgelines and in adjacent bowls. Most of these slides were from newly formed wind slabs from previous days of northwest wind transport. We had used explosives and ski cut these slabs inbounds the day prior to the quake with no results. Looking out into the adjacent ranges of the region we could see bowl after bowl filled with debris, even many kilometers to the west and well away from the earthquake epicenter.

Satisfied with what we were seeing inbounds, and considering that there could not have been a better test of our snowpack, we rated the stability for the ski hill Very Good and opened to the public. Over the next few hours and days the subsequent damage from the quake became all the more real. Much of the Craigieburn Range and the ranges around were reporting large out-of-bounds avalanches, some stepping down into old layers. This had been one of the largest natural avalanche events in the history of the region. There were, however, no reports of any inbounds avalanche activity and no major infrastructure damage.

In Christchurch the story was not so good. Many buildings and homes were destroyed or damaged beyond repair, and thousands of people were without power or water for several days after the quake. The magnitude of this earthquake was the same as the earthquake that struck Haiti on January 12, but in New Zealand no deaths occurred and only minor injuries were reported. Aftershocks continue to rattle the region, some as large as magnitude 5, and it will take some time before the region returns to normal.

Brad Carpenter is the snow safety director at Moonlight Basin ski area in Montana and spends his summer ski patrolling in New Zealand at Porters ski area.

EARTHQUAKE AVALANCHES

continued from previous page

Arrowsmiths region indicates that snow and wind continued throughout the night and that a substantial amount of new snow and loading would have occurred on the slopes lee to the western half. The lee slopes (S to E) were now primed and only lacked a trigger.

Avalanches Reported

In the Mount Hutt/Arrowsmiths region multiple slab avalanches from size D1 to D3 released on slopes above 1500m. These avalanches were mainly reported on slopes of the eastern half, but were reported to have occurred on all almost all aspects. The avalanches in the Mt Hutt region had particularly wide and jagged fractures, with one observer noting that they had propagated "differently" to that which was expected for these start zones.

Methven Heliski reported that they "observed a significant natural cycle in the Palmer Range that was caused by the earthquake. Most slides were in the 2000-1800m [elevation] range, mostly size 2, and all on S/SE aspects. Weak layers were the facet and surface hoar combination buried by 40cm HST on 3008 [August 30] and drifted to 140cm crown thickness in some areas. Observed no natural activity on solar aspects. Skied adjacent to slide paths and found good stability thanks to earthquake" *(Figure 5)*.

The surface hoar was thought to be the main sliding layer, and this had grown out of a hard crust and was considered to be quite resilient. The southern and southeastern aspects were the locations where the surface hoar was not destroyed by wind or solar radiation and was believed to be buried intact. In the Palmer Range it was estimated that around 95% of the avalanches observed were on the south and southeastern aspects *(Boekholt pers comm., 2010)*.

In the Craigieburn Range multiple slab avalanches from size D2 to D3 released on slopes above 1800m. These were all reported on southern and southeastern aspects and were thought to have either slid on the buried surface hoar layer (100824) or in the facets and rain crust layer of August 18 (100818). They were generally over 1m deep and 200-500m wide *(Figure 6)*. Numerous similar "Ne" (Natural trigger, Earthquake) occurrences were also observed across the wider Craigieburn, Torlesse, Grey and Black Ranges *(Jackson pers comm., 2010)*. In terms of overall scale, the maximum distance from the epicenter to a confirmed avalanche caused by the earthquake was approximately 100km, but unreported avalanche events might have occurred further away.

In addition to the reported avalanche events, large cracks to the full depth of the snowpack were observed in the Mt Hutt range. These cracks had the general appearance of glide cracks and extended over 30m on southeast through to southwest faces. These cracks were generally in the 1800-2000m elevation range but were also been observed at lower altitudes. Similar cracks were noted at Mt Dobson ski area, approximately 100km away. Unfortunately, new snow covered these cracks shortly after the earthquake and monitoring of them was not possible. Now with the spring melt, these cracks have re-emerged and the Mt Hutt ski patrol are watching them with great interest. While the cracks were initially observed on slopes with an angle of greater than 30 degrees, they are now appearing on much flatter terrain *(Figure 7)*. The Mt Hutt ski patrol has suggested that they may have been caused when the shingle bed surface was pulled away from the snowpack during the earthquake and the unsupported snowpack is now slumping and cracking. Likely these full depth cracks are not isolated to just this area. However, neighboring ski areas (such as those in the Craigieburn Range) have now closed for the season and no other reports of similar large cracks have been received.

Discussion & Conclusions

The earthquake triggered widespread avalanche activity throughout both regions, with reported events ranging in size from D1 to D3. The avalanches were predominantly on south and southeastern aspects, but did occur elsewhere as well. Based on very limited observations, the consensus seems to suggest that the avalanches primarily occurred in the layer of buried surface hoar. The south and southeasterly aspects likely had the most developed facets and surface hoar due to their generally more shady exposure. They were also lee slopes during the prior storms and definitely experienced substantial new snow loading. Interestingly, western and northern slopes only saw isolated events, likely due to the general absence of the surface hoar layer on these aspects. Additional to the avalanche activity, full-depth cracks have also been observed in the Mt Hutt Range, and these are likely to be present elsewhere. These cracks may end up behaving like glide cracks as we progress into spring, but since no one has experienced them in these locations before (unlike a glide crack with a "normal" location), they remain a concern.

The modeled and reported forces exerted by the earthquake (as measured by the MM scale) were less over the alpine regions than those felt in Christchurch. Despite this, the PGA instruments still recorded values of between 8 and 15% gravity (at Arthur's Pass and Oxford respectively), meaning that a horizontal force of about 0.08 to 0.15 times the normal load due to gravity was exerted on the snowpack. This shaking was clearly enough to cause substantial avalanche activity on aspects where the right mix of layers and loading was present. Given the nature of the weakness and the additional wind loading, these aspects may have avalanched anyway with further loading, but it seems very likely that the shaking from the earthquake triggered these avalanche events. This may be one of the first recorded events where we can identify the role of grain type on earthquake-induced avalanche activity, but further work will be needed to provide any further insight on this matter.

We were very fortunate that the earthquake occurred at 0430 in the morning and not at 1100 on a busy Saturday, as some of these slopes may not have seen active control and could have caught us unaware.

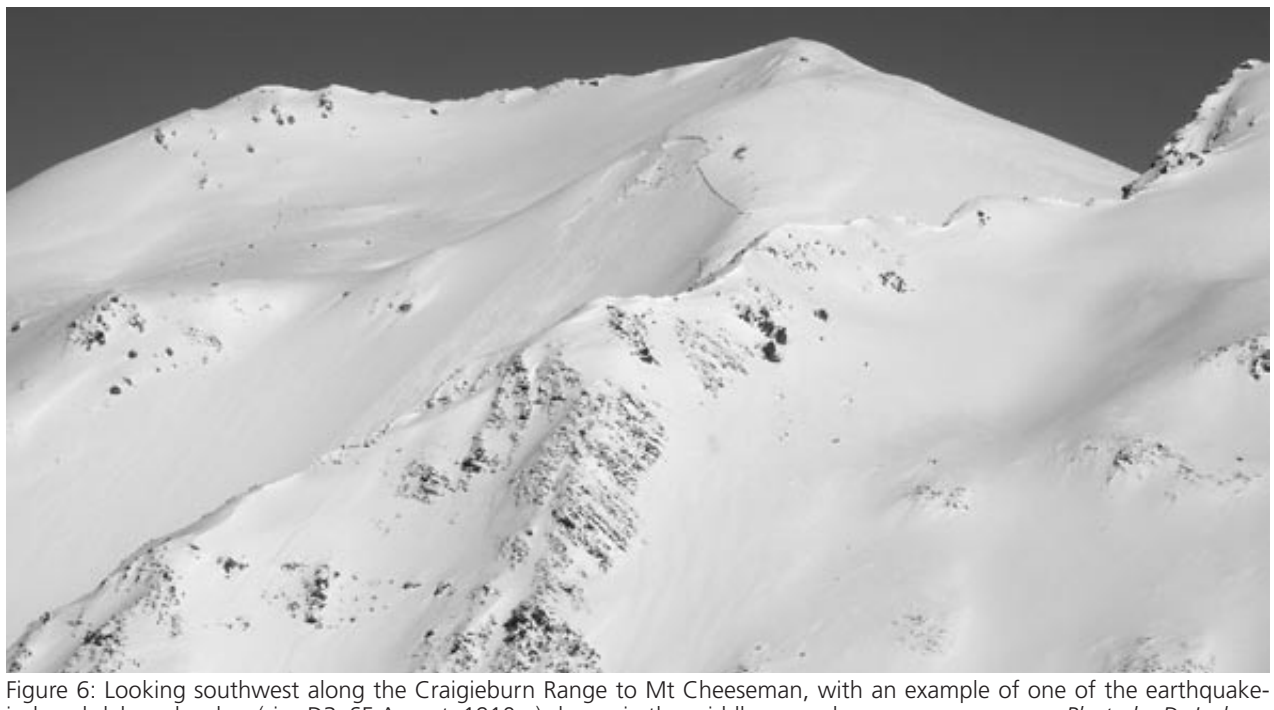


Figure 6: Looking southwest along the Craigieburn Range to Mt Cheeseman, with an example of one of the earthquake-induced slab avalanches (size D3, SE Aspect, 1910m) shown in the middle ground. *Photo by D. Jackson*

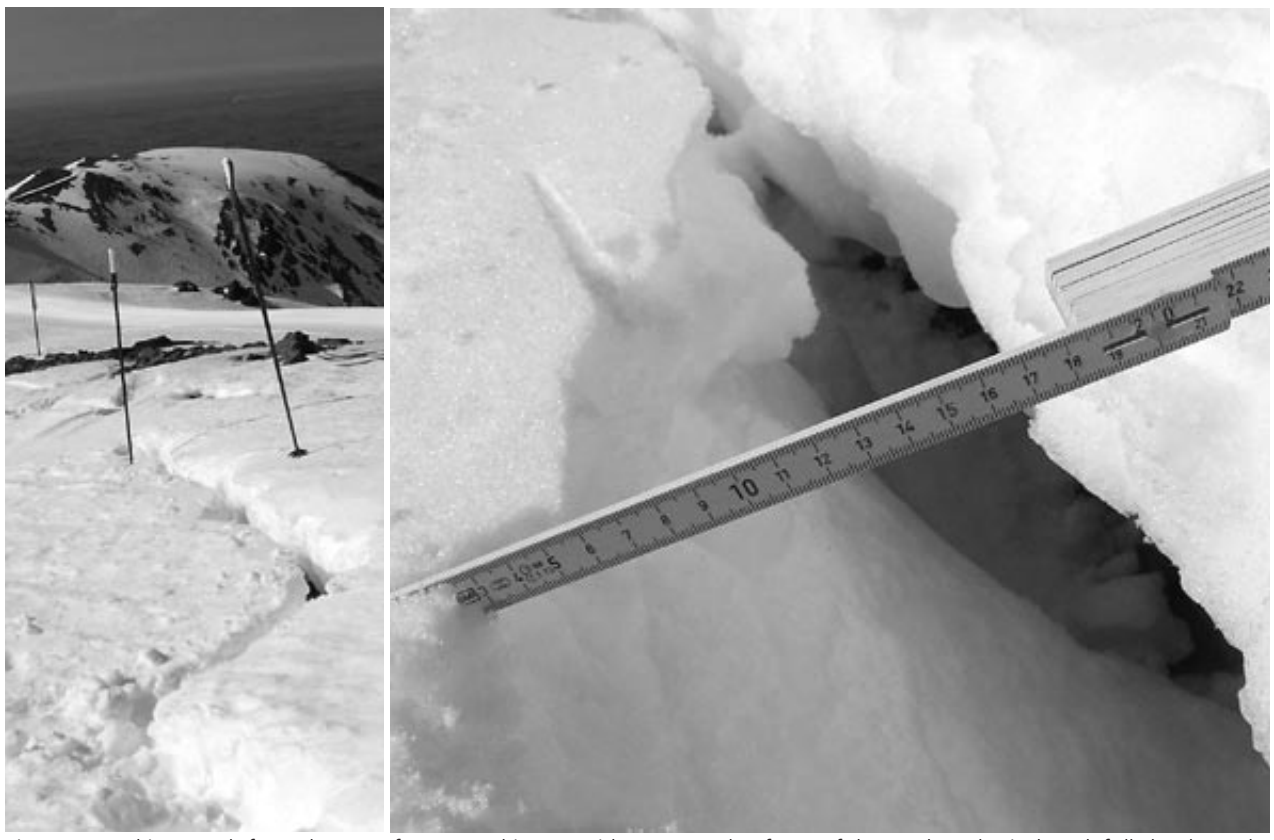


Figure 7: Looking south from the top of Mt Hutt ski area, with an example of one of the earthquake-induced, full-depth cracks shown in the foreground (left) and up close (right). *Photos by R. Mguire*

Acknowledgments

We acknowledge the New Zealand GeoNet project and its sponsors EQC, GNS Science and LINZ for providing data and images used in this study. We also acknowledge the ongoing snow, weather, and avalanche observations from all contributors to the New Zealand Mountain Safety Council Avalanche.net, but in particular the lead forecasters for the two regions (Kevin Boekholt and Damian Jackson), Methven Heliski, and Mt Hutt, Porters, Mt Cheeseman, Broken River and Craigieburn Valley ski areas.

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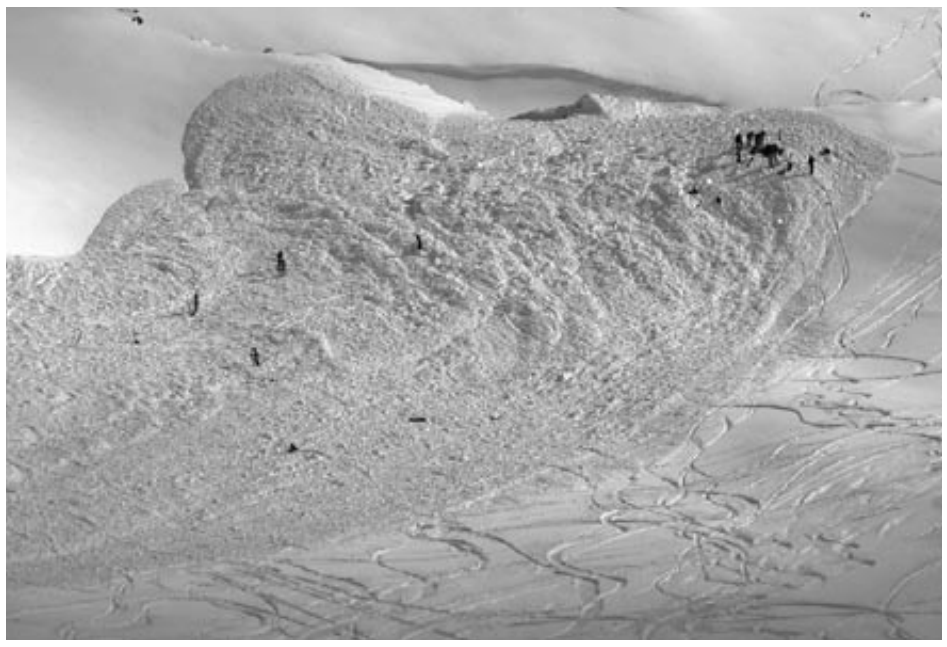
Jordy Hendrikx will be moving to Montana in late December to take up a professorship at Montana State University in Bozeman, where he will be leading the Snow Science program in the Department of Earth Sciences. In addition, he and his wife are the proud parents of daughter Sophie, who arrived on September 24. He relates that, "All is going well with her and us, albeit with less sleep."

Avalanche Analysis: France 2009/10

Story by David George

The 2009/10 ski season in France saw 41 avalanche fatalities in 33 incidents. The number of incidents is the worst figure since 1989/90 except for the winter of 2005/06. Worryingly for the avalanche educators and the rescue services, the last three seasons have seen a sharp upward trend in both fatalities and incidents which can only partially be explained by the snow conditions.

Avalanches in the Chartreuse forests. *Photo by David George*



Victim receives medical care at Val Thorens.

The 2009/10 winter in Europe will be remembered as one of the harshest for a generation. High-speed rail services ground to a halt as motors and overhead wiring failed to cope with the arctic conditions. Satellite imagery showed Britain frozen like a scene from a disaster movie. While Northern Europe was hit by successive blizzards, the conditions further south in the mountains were cold but relatively dry.

The first skiable snow fell at the start of November 2009 but the joy was short lived. The end of November saw a snow drought and an Indian summer in the alpine valleys. There was fresh snow at the start of December with a spell of very cold weather from December 12-21. By the second half of the month all mountain ranges had snow cover, but conditions in the Northern Alps were only normal from 2300m and strong winds had affected conditions higher up. Ski resorts were able to operate normally as the cold weather was ideal for snow making.

January saw below-average temperatures and a lack of snowfall, although this was less pronounced in the south and in the Pyrenees. The cold weather meant that snow conditions, even at low altitudes, were good. It was possible to tour from 600m. The first half of February saw another cold snap, but snowfall over much of the Northern Alps was well-below average. Frequent small falls and cold temperatures meant excellent skiing conditions especially at altitude. Strong winds, frequently from the northwest to southwest, affected the cover at altitude. March saw rain to 2200-2600m with new snow in the middle of the month. Touring conditions were excellent in the spring through late June when there was unusual snowfall down to 1800m. There was fresh snow at high altitudes during the summer and early autumn, but no fatal incidents were reported during this period.

SNOWPACK

Anyone interested in avalanches might already be concerned about the lack of snow depth and cold temperatures at the start of the season coupled with the strong prevailing westerly winds. Conditions similar to the deadly winter of 2005/06, when a layer of depth hoar formed at the start of winter and instabilities persisted throughout the season. The rain in March could be expected to have cleaned out this weak layer. With snow cover at all altitudes and across all French mountain ranges, one could also imagine that the risk was more generalized than normal. Indeed snowshoers and ski tourers were surprised by avalanches in places such as the wooded Chartreuse valleys.

Following high-profile deaths of rescue workers in Switzerland and Italy and the death of a client in an instructor-led group at Val Thorens, as well as three skiers including a guide at les Arcs, the mainstream press picked up on the unstable conditions. At the start of January, a journalist for the British newspaper, *The Guardian*, wrote, "2009/10 season could spell disaster." However, an analysis of fatalities in both Switzerland and France for the start of winter showed nothing particularly alarming. The rate of incidents only overtook a normal winter at the end of January. What was noteworthy was that even light snowfall was enough to trigger a series of incidents.

INCIDENTS

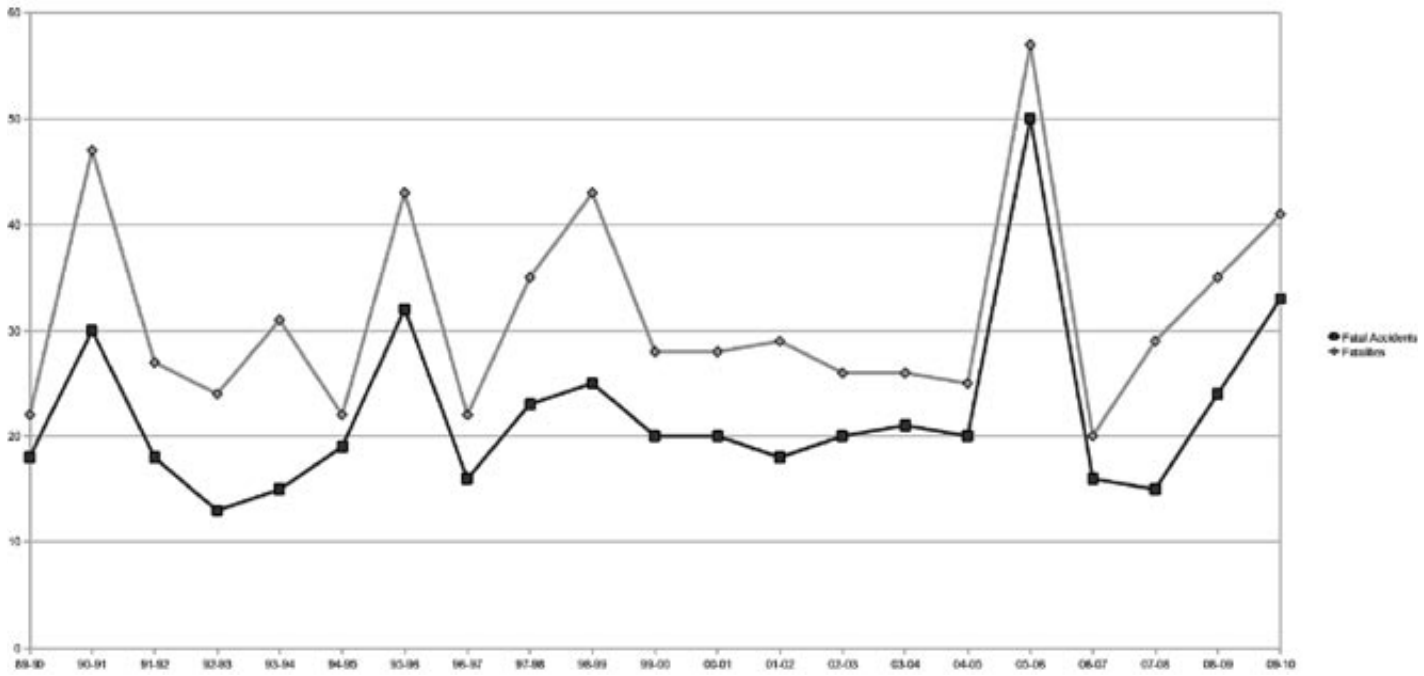
The first fatality was on December 23 in the Southern Alps following heavy snow across the Alps. In total there were 13 incidents with three fatalities in the four-day period from December 22-26. Luckiest perhaps was a British lady rescued at Valmorel thanks to Recco reflectors on her ski boots. The avalanche risk fluctuated between 4 and 5, and two large powder avalanches hit the road above la Grave.

After a brief respite over the New Year period, an instructor-led group was hit by an avalanche triggered by a group skiing above on a popular route close to Val Thorens *(see photo above)*, and three skiers including a high mountain guide were killed in the notorious NNE-facing Combe des Lanchettes at les Arcs. The group were equipped with ABS airbags which they had deployed, but the scale of the avalanche buried the skiers under 5-10m of snow. ABS give the chance of dying when an airbag is activated at 1:77, but statistics have little power against a massive avalanche. The avalanche bulletin had warned of up to 70cm of fresh snow accompanied by southwest winds and noted a weak layer. The guide's father, Alain Gaimard, pointed out that a simple cord separates "Disneyland" (les Arcs) from the "High Mountains" and that a solution must be found to resolve this contrast. Patrick Quincy, the state prosecutor for the area, also asked the police to be on the lookout for skiers flouting regulations.

January 16 saw a rare piste fatality when a retiree was killed in the tiny Pyrenean resort of les Olmes. It appears that the slide was triggered by snowshoers on the ridge above the piste. The avalanche risk was 4 following a rapid thaw. Both the victim and snowshoers were local to the resort. After an extensive investigation by the authorities, no further action was taken.

The French winter holiday period was to see a hecatomb *(Ancient Greek: a sacrifice to the gods of 100 cattle)*. In the period from January 31 to March 6 there were 16 fatal avalanche incidents, twice the average. The period was bracketed by the deaths of two experienced and well-known extreme skiers on steep and exposed routes. The first in the Chartreuse, the second in the Vercors; both areas where fatal avalanches are comparatively rare. During the month the Massif Central, Pyrenees, Southern and Northern Alps also saw avalanche fatalities. Corsica was also touched during the winter – an indication of the widespread nature of the avalanche risk.

High-altitude rain and a good freeze-thaw cycle, along with the end of the school holidays, stopped the carnage in



Avalanche deaths and incidents since 1989/90

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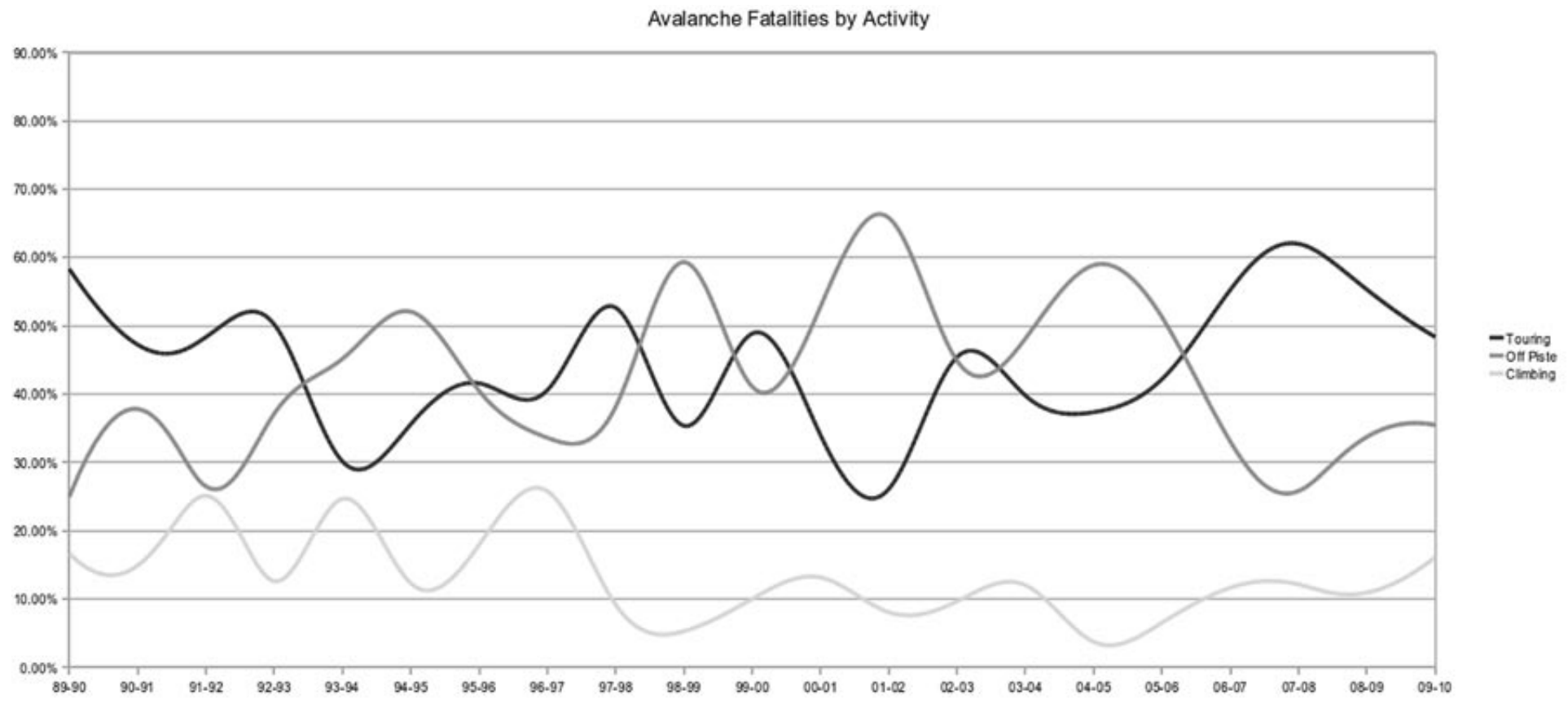

FRANCE 2009/10

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early March. The final avalanche cycle began early in April over the Easter weekend, killing seven people in five incidents. This led to a rare intervention by the rescue services who warned skiers off the mountains. In the Isere department seven rescue missions were flown in the space of two hours in difficult conditions, high winds, and drifting snow. With conditions clearly visible from the valley, many groups made U-turns, but others persisted in the face of facts.

In the Haute-Savoie three experienced skiers were killed just below the pass descending into the Vallon de Bérard. Guide, extreme skier, and author Anselme Baud spoke out against "group suicides" and experienced skiers ignoring "simple safety rules" and the fatalistic attitude in the Chamonix valley. "The skiers arrived together from above on a big convex slope where, even in stable conditions, you would look, then ski one by one. Three of them skied together, breaking the fragile anchors between the big slab of snow resting on a rain crust. Where the slope is really convex, the worst of situations. The three skiers chose to stop. Why at that spot in the middle of that vast slope?"

SUMMARY

As in 2005/06, we see that early conditions with thin snowpack and cold temperatures can have a major effect on the stability of diverse slopes throughout the season. However, the actions of backcountry travelers were a significant factor in the poor figures.

Seven fatal accidents, nearly a quarter of the total, involved lone skiers. This nearly always precludes the rapid intervention of rescuers vital to a successful outcome and involves the SAR in long searches in difficult conditions. In the case of a soldier found at Mont Saconnex in March, the operation lasted 27 days.

Of the 31 fatal incidents where an avalanche bulletin was issued, 7 (23%) occurred at risk 4 and 19 (61%) at risk 3. On the five-point avalanche scale risk 5 concerns infrastructure so for backcountry travelers risk 4 should be seen as the maximum, and risk 3 is in the upper zone.

Frustrated ski tourers complained that the avalanche risk seemed to have been "stuck at 3" for the entire winter and that there is a time "when it just becomes meaningless" to quote a couple of messages posted to the skitour.fr forum. Over 80% of days from January to March were risk 3 in the Belledonne. The Easter incidents were also partially a consequence of frustration with a winter of poor weather, especially at weekends. L'Alpe d'Huez recorded less than half the normal days of sunshine. Research has shown that two out of three ski tourers can correctly give the avalanche risk, but only one in three can recall the details of the bulletin. To address this problem Meteo France trialled a simplified, graphical avalanche bulletin for each mountain range rather than covering a whole department. This new bulletin will be rolled out this winter.

Avalanche in the Vallon de Bérard, Vallorcine.
Photo by Alan Scowcroft

The number of experienced skiers and professionals involved in incidents is a continuing worry. The Savoie Prefect ordered an investigation following the deaths at Val Thorens and les Arcs at the New Year. Anselme Baud expressed alarm at the number of professionals killed over the last 18 months. There is certainly distinction to be made between snow professionals – with defined training but with commercial pressures to find good snow for clients – and "experienced" skiers – who may have no formal training and rely on heuristics picked up during their time in the mountains.

The proportion of ski tourers and snowshoers in the statistics seems to have finally leveled out, indicating an equilibrium may have been reached with off-piste skiing after a rapid growth in adventure skiing over the last five years. The number of deaths of climbers this season is probably an anomaly, but climbers on winter routes should certainly consider avalanche rescue gear. Once again we note that off-piste skiers and snowshoers frequently do not carry avalanche transceivers, leading to long and probably fatal delays in rescue.

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David George runs the ski touring Web site www.pistehors.com. He is a dependable European correspondent for The Avalanche Review.

Swiss See Sharp Rise in Ski-Touring Fatalities

Story by David George

According to figures from the Swiss Snow and Avalanche Research Institute, 68% of avalanche victims during the winter of 2009/10 were ski tourers. The average over the last decade is 42%. In total, 29 people were killed by avalanches last season. The average since 1998/99 is 24. The number of fatal incidents was 22, the highest figure since 1998 and more than double the average of 10.5.

The snowpack was unstable over a long period and over an extended geographical area. In total 20 of the victims were ski tourers. Out of the 22 fatal incidents, 15 were ski-touring parties, two were out-of-bounds snowboarders, two were out-of-bounds skiers, one was a snowshoe group, and one was a group on foot. Another snowboarder was killed while on foot recovering his board.

In five of the incidents, the victim was not wearing an avalanche beacon, which significantly delayed the rescue. All but one of the fatal incidents occurred at risk level 2 and 3. The long-term average for these risk levels is 75%.

The most serious avalanche was on January 3, 2010, in the Diemtigtal, killing seven people and burying 12. A secondary avalanche hit a rescue party including a doctor dropped by helicopter at the scene.

US Season Summaries 2009/10

Continued from TAR 29-1

NW Montana Glacier Country Avalanche Center

For Northwestern Montana the winter of 2009/10 was a dynamic one, generally characterized by warmer than normal temperatures and below-normal snowfall. In early October we experienced the first of three sub-zero weather events. Arctic blasts were repeated again in early December and early January. Outside these cold episodes however, temperatures were generally at or above normal.

Rain-on-snow events in late October and again at Thanksgiving combined with the sub-zero bouts to produce instability near the base of the snowpack that persisted through most of the winter. The month of December was a snowy one, but then in early January the moisture switch flipped to "off." The dry spell continued through February and on to the end of March, with only occasional interruptions of new snowfall. Dry conditions combined with clear skies and cold nighttime temperatures to produce near-surface instability and to maintain buried instabilities existing near the middle of the snowpack. These buried instabilities produced several near-miss avalanches involving snowmobilers in February and March and at nearly the end of the forecast season our one fatal avalanche.

In late March a fast-moving Pacific storm system with heavy snowfall and strong westerly winds set the stage for Wednesday, March 31, when a lone backcountry snowboarder triggered a soft-slab avalanche off the east face of Peak 6996 in the southeastern corner of Glacier National Park. Carried into a stand of sapling evergreens, the victim sustained significant trauma injury. After self arresting, he was able to first board and then hike an additional 650 vertical feet before collapsing. He was found deceased the following day by friends, disturbed when he failed to answer cell phone calls and text messages.

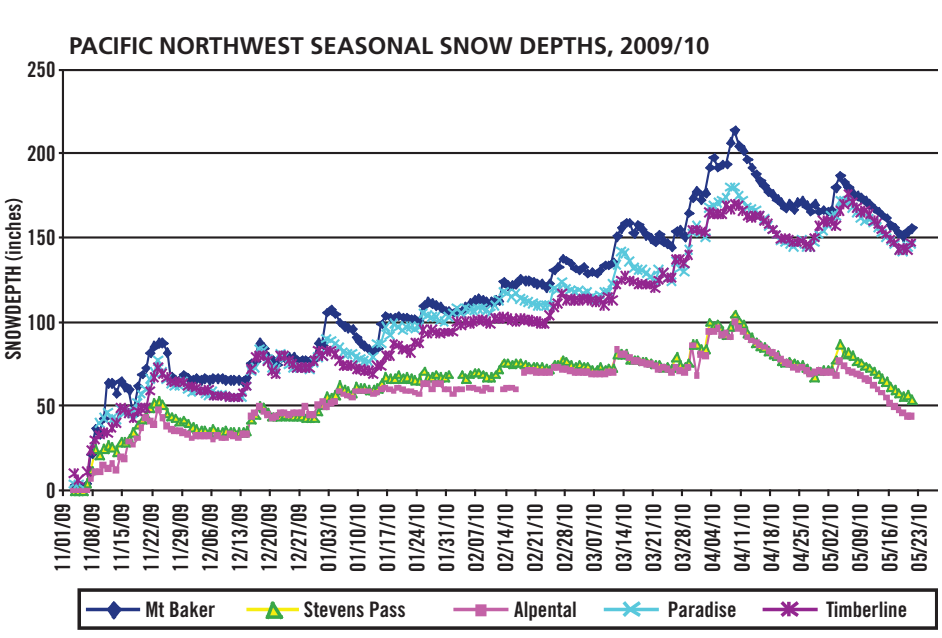
The avalanche center's education program was a success again this year with returning Forest Service seasonal employee, Leah Taylor. Numerous public transceiver and avalanche-awareness sessions were offered and well attended, along with presentations to elementary and secondary school classes.

Flathead National Forest again presented two separate advanced avalanche-awareness training sessions. These sessions involve 12 hours in class and 12 hours in the field. The earlier one in January focuses upon skiers, boarders, and mountaineers. The second in late January and early February targeted snowmobilers.

The twice weekly, regularly issued avalanche advisories are posted on the GCAC Web site and offered via email and recorded phone hotline. The Web site received a new face lift this year, and further refinements are planned for next season. The Web page not only provides access to our advisories, but also is a forum for backcountry observation reports. The Forest Service received another grant for avalanche education from Montana Fish, Wildlife & Parks. Our plans for next season involve maintaining our programs and expanding where funding allows.

—Tony Willits & Stan Bones, avalanche & snow specialists, Flathead National Forest

March 31, Peak 6996 avalanche, Glacier National Park, looking up slope at the crown and path. *Photo by Erich Peitzsch, USGS*



Northwest Weather and Avalanche Center

The winter season's weather in the Pacific Northwest for 2009/10 could be characterized by the image of a very thick book, substantially bound by impressive covers, yet filled with pages and pages of relatively fluffy material: the heavy thick binding referring to the rather impressive weather received both at the beginning and again at the end of the season, with the bulk of the chapters that constitute the core of the season filled with rather unimpressive conditions.

The end result of the winter's weather was not, however, unexpected. Going into the season, strengthening El Niño conditions in the tropical Pacific were well advertised. The classic El Niño pattern often translates into rather mild conditions in the Pacific Northwest with the upper level flow dominated by a strong split in the Pacific westerlies. This pattern did in fact emerge during the core of the season with the strongest flow generally being directed both north of the area and south towards California.

The recurring split flow in the eastern North Pacific produced benign weather in the region. Despite the rather boring weather pattern, the resultant snowpack conditions were frequently anything but. This was due to the combination of numerous strong crust layers (not unusual) coupled with extended fair weather periods (very unusual). The frequent fair weather periods allowed for significant surface hoar development. Many of these layers were buried by light snowfall events to become activated following the few storm cycles that did manage to reach the area.

The season began in earnest in early November with a series of strong storms. For example the weather station NWAC maintains at the Mt Baker ski area recorded over 20" of water in a nine-day period between November 14 and 22. Little to no snow existed at this station on November 5, yet the snow depth on the ground reached 88" by November 23. This depth was not eclipsed until after the New Year. Heavy rain events to high elevations occurred within this period in late November and especially near Christmas when freezing levels topped out over 10,000' *(For those reading this in Colorado, that is HIGH here!)*. This weather produced avalanche cycles, knocked back the snow depths, and formed strong crusts. The subsequent "Christmas crust" became a definitive layer for avalanches early in the New Year.

The single avalanche-related fatality in the Northwest occurred outside of the NWAC forecast area on January 2 in the Paulina Peak area of central Oregon when a lone snowmobiler triggered a slide that subsequently buried and killed the rider. Fracture profiles of the slide identified a significant buried surface hoar layer that had formed above the Christmas crust during fair weather prior to the storm cycle preceding the accident. Similar conditions were being experienced within the area covered by daily forecasts provided by NWAC. The NWAC weather stations nearest to the accident are located in northern Oregon on Mt Hood, where 2' of recent snow had fallen. The fracture profile would indicate similar amounts of recent snow had accumulated there as well, creating a classic deadly scenario of recent wind slab sitting over a surface hoar layer above a smooth, hard, sliding surface. There were many close calls in the Washington Cascades and the Mt Hood area during this time as well.

The remainder of January was dominated by the split-flow pattern, indicative of the meager snowfall amounts recorded in the area. Following the storm cycle that carried into the first few days of January, Snoqualmie Pass recorded only 34" of snowfall the remainder of January. February continued this pattern as the WSDOT on Snoqualmie Pass measured only 13" of snowfall for the entire month!

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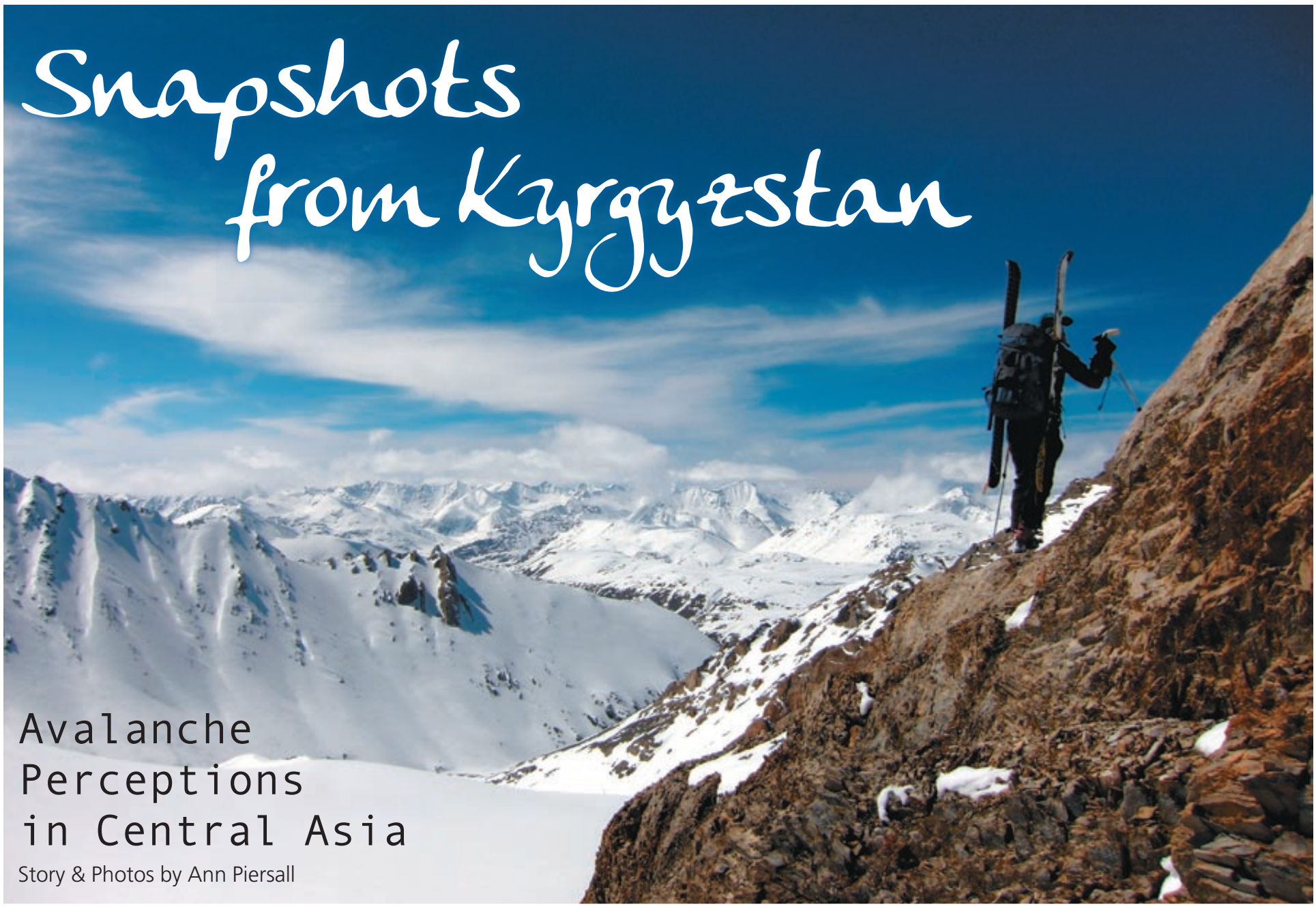

Snapshots from Kyrgyzstan

Avalanche Perceptions in Central Asia

Story & Photos by Ann Piersall

Feelings of foreignness are evoked in many situations. Some of us feel out of place standing in a lift line; others feel alien walking through a busy city. Regardless of the situation, the qualities of being foreign – utter bafflement, disorientation, incongruity – remain the same. For those of us who thrive on the learning that comes with uncertainty, the most satisfying experience is spending extended periods of complete immersion in a world other than our own. It was these experiences I sought when I moved for a year to Kyrgyzstan, a small rugged mountainous country in Central Asia.

THE BEGINNING

Located thousands of miles from the nearest ocean, the huge relief of the Tien Shan Mountains draws snow and rain on what would otherwise be a vast desert. With peaks cresting 23,000', the complicated terrain creates immense cultural, political, and economic challenges for locals. However the physical landscape has sculpted the cultural landscape. The high mountains serve as a source of Kyrgyz ethnic identity, and natural resources are the basis of all livelihoods. For skiers and alpinists the mountains provide unlimited opportunities.

I knew the terrain in Kyrgyzstan would provide ample opportunities for skiing and climbing, but arriving alone, I was unsure with whom I could pursue these opportunities. During my first weeks, as I figured out transportation, customs, and the language (Russian and Kyrgyz), bitter cold set in, and the first layers of snow blanketed the country. By December I was overeager to get out.

In the capital city of Bishkek, I met a Russian man who skied. In a mix of broken English and a few Russian words our first conversation revealed that he owned no safety equipment, only touring gear and skins. I lent him my extra beacon, shovel, and probe, and we headed to the towering Kyrgyz Ala-Too Range just south of the city. As he furiously smoked a cigarette, I was able to hold his attention just long enough to demonstrate how to put on the beacon. It ended up in his backpack. On our ascent, as he casually began putting in a skin track on an exposed wind-loaded slope, I had the fleeting feeling I might be better off touring alone. I called out, asking if we should ascend the ridge instead. He paused, if only for a second, and turned to face me. As if taking a page from the stereotype of the steely, stoic Russian mountaineer, he replied simply, "I always make ascent. No problem."

A week later I was invited on an overnight ski tour to an abandoned Soviet hut with two Europeans. They promised a "quick and easy" ascent despite their "limited backcountry experience." Walking in, the snowpack was deeper than I had anticipated. Digging revealed an impressive layer cake of facets that would lose its shock value as the season wore on. After a full day of travel, darkness was falling, and an argument ensued between my two companions about our location. We finally came to the consensus that instead of relying on their fuzzy memory of the route, we should resort to navigating off an old Soviet map. Moving at a snail's pace across huge moraines, their skins failed within an hour. As they shuffled through the deep snow, I shuttled their enormously heavy packs wondering with what they could possibly be stuffed? At midnight we finally reached the hut. We had traveled just two kilometers over the past six hours since nightfall. The following day I watched them unpack a dozen loaves of bread, four kilos of cheese, 20 chocolate bars, endless sausages, and bags and bags of dried fruit. We didn't get much skiing in, but at least we ate well.

The Uzbek children were thrilled to get out on skis.

left: Even with tenuous conditions, there was good skiing to be found in lower-angle terrain.

right: The Kyrgyz locals take advantage of the tree-felling power of large avalanches to harvest firewood.

Careful planning put camp out of the runout of this large avalanche slope, but there are always a few frightening moments when theory is tested.

Caught with My Pants Down

Three women on an exploratory ski expedition to Kyrgyzstan

Story by Jaime Musnicki

We had just moved camp on our seventh of nine days exploring and skiing in the Jetim-Bel range of central Kyrgyzstan. Having finished digging out a beautiful snow kitchen, I skinned about 20 feet away from where my partners, Molly Loomis and Ann Piersall, were setting up our tent, pulled my pants down around my knees, and squatted to pee. I was midstream when I heard and felt the initial huge collapse. I glanced quickly over my shoulder at the slope looming above our camp. We had diligently taken alpha angles in selecting our new campsite at the mouth of the mile-wide drainage, but that slope still looked pretty close. As I looked back toward Molly and Ann, still peeing, I heard the collapse propagate further across and up the valley. I glanced again over my shoulder and this time watched the slope behind me shatter. As the snow started sliding, it triggered more and more of the slope. Though I wasn't quite finished peeing, I quickly stood up, yelled some expletives, and started skiing away from the slide as I pulled my pants back up. The dense, hard-slab debris came to a stop about 150' from our camp.

Triggering and watching this avalanche (HS-ASr-D3.5-R4-O) from our camp was one of many great learning experiences for all three of us on our expedition to Kyrgyzstan. We were humbled by the immense power of the snow coming down the slope directly toward us. Throughout the previous seven days we had been making rather conservative terrain decisions in our ski explorations due to the consistently weak and scary snowpack we were finding on a variety of aspects. Snow depths were in the 75-85cm range on average, with the lower half of that depth generally being advanced facets and depth hoar (crystals of 10+mm). Poor structure, moderate to high energy, and variable strength had us sticking to moderate terrain. As a team, we were very aware of and communicated clearly about not wanting to get caught in any avalanches. On a number of occasions our decision- making process touched on wanting to make sound decisions and not just "get away" with skiing a particular slope. We had a high level of awareness of being in an extremely continental snowpack and of being in a relatively remote area of a Central Asian country that did not have the support systems we were accustomed to in the States.

I admit to feeling myriad human factors, wanting to ski steeper lines and push the boundaries a bit more, on a number of occasions. We had come so far to explore this area. The possible lines in this small slice of Kyrgyzstan were seemingly infinite and beautiful. Our expedition was being supported by generous funding from the Hans Saari Memorial Fund, and I wanted to accomplish as much as possible to justify their support. We had already encountered so many hitches in our plans that limited our actual time in the mountains and changed the objectives we pursued; I wanted to make the most of the time we did have.

I credit our diligent data collection, observations, and analysis – as well as our clear, honest communication as a team – with keeping our numerous human factors adequately in check. As the snow was sliding down toward us that day, I was awed, yet also confident that we were in a good position. All of my questions about whether we were being too conservative were clearly answered with that one event. The hazard was real, and we had been making sound decisions.

Overall, I would deem our expedition a success. We spent nine days living in and exploring a previously un-skied area in Kyrgyzstan. We skied from the top of two different peaks in the area, explored and skied a number of ridges, and completed a few longer tour days traversing back and forth across the range. We stuck our heads into the snow frequently, made good decisions, worked well as a team of three, and had tons of fun in the mountains together. We handled a number of unanticipated events – a revolution, no access to money, a non-functioning satellite phone that spoke to us in Russian, the late-breaking discovery that our main "historic second descent" ski objective was now being mined for gold, and the list goes on – with positive attitudes and the understanding that it was all part of the adventure for us. The lessons and stories from our adventures are copious. Flexibility and a willingness to deal with whatever obstacles were thrown our way were keys to our success and enjoyment of the expedition. Who knew a ski expedition to Kyrgyzstan would ever result in so much more than just skiing?

Jaime, Molly, and Ann are incredibly grateful to the Hans Saari Memorial Fund for their generous support of this all-women's expedition. The Hans Fund is based in Bozeman, MT, and supports ski exploration and youth avalanche education. To learn more about the Hans Fund and how you can contribute support or apply for a grant for ski exploration, visit www.hansfund.org.

Jaime Musnicki resides in Teton Valley, Idaho, when she is not out and about teaching backcountry skiing, glacier mountaineering, or rock climbing courses for NOLS. She loves snow, cold weather, and skiing. This trip to Kyrgyzstan was her first foray into international ski exploration. She is now solidly hooked on the craziness of combining skiing with international travel. If you are interested in hearing more stories from Kyrgyzstan, contact Jaime at jmusnicki@gmail.com.

THE LOCALS

As the season wore on, a common language and a shared interest in safety were my highest priorities in selecting ski partners. Word of mouth presented me with an invitation to a small Uzbek village in southern Kyrgyzstan to teach basic avalanche safety and ski lessons to village children. I had recently found two savvy friends: a traveling NOLS employee and a wise ex-pat Alaskan climber married to a Kyrgyz woman. Together, we traveled to the village of Arslanbob. A typical day touring with the Uzbeks consisted of elaborate morning greetings, complicated logistics regarding the allocation of skis, a lengthy lunch, and optional stops five times daily for the more conservative Muslim guides to stop and pray.

Speaking with the guides it was revealed to me that the winter climate had changed within their lifetimes. An increased occurrence of avalanches correlated with more frequent winter rain events. Most of the men were unable to travel in complex terrain due to their beginner skiing skills. However, many also voiced religious and personal fears of snow, stating that "the big snow slide" was only controlled by Allah. A few years prior, a local had been killed by an avalanche just above the village while hunting. One guide confided in me that this hunter was killed for his sins: drinking too much vodka and not attending the mosque.

AVALANCHES ONLY HAPPEN WHEN…

In February, I was joined by an educated Colorado couple doing reconnaissance for a backcountry yurt operation in the eastern part of Kyrgyzstan (www.fortytribesbackcountry.com). During multiple week-long backcountry tours with them, the greatest logistical challenges were simply getting to the mountains. Locals could not fathom our interest in spending a week in the mountains in a tent, and many were skeptical of our ability to care for ourselves. We took humor in the experience, yet our explorations revealed incredible potential in previously unskied areas. However, persistent weak layers kept us cautious. On ascents, shooting cracks and collapsing became a daily occurrence.

Recovering from a particularly cold trip, we were convinced to visit a local hot spring owned by an eccentric white-mustachioed Russian, heavily involved in summer tourism. Turning off the main road in a blizzard, our 4x4 van was blocked from traveling further by recent avalanche debris. We still had 25km to travel with the snowfall escalating in intensity and temperatures warming. Though we were ready to turn around, our Russian host would not permit it. He responded to our warnings about increasing avalanche danger by opening a bottle of cheap cognac and passing shots around the car. "Avalanches only happen after 8pm," he assured us. With a buzz and no visible alternative, we skinned in, crossing numerous avalanche paths en route. A few had released and locals were busy chopping trees out of debris for firewood.

The following day, after a morning of soaking, we retraced our tracks to find that every single avalanche path we had crossed had run full track. Only after several days would we learn the full magnitude of the storm and of its regional ramifications. After an extended dry period, the

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Old and new encounter one another; Kyrgyzstan slowly enters the twenty-first century.

KRYGYZSTAN

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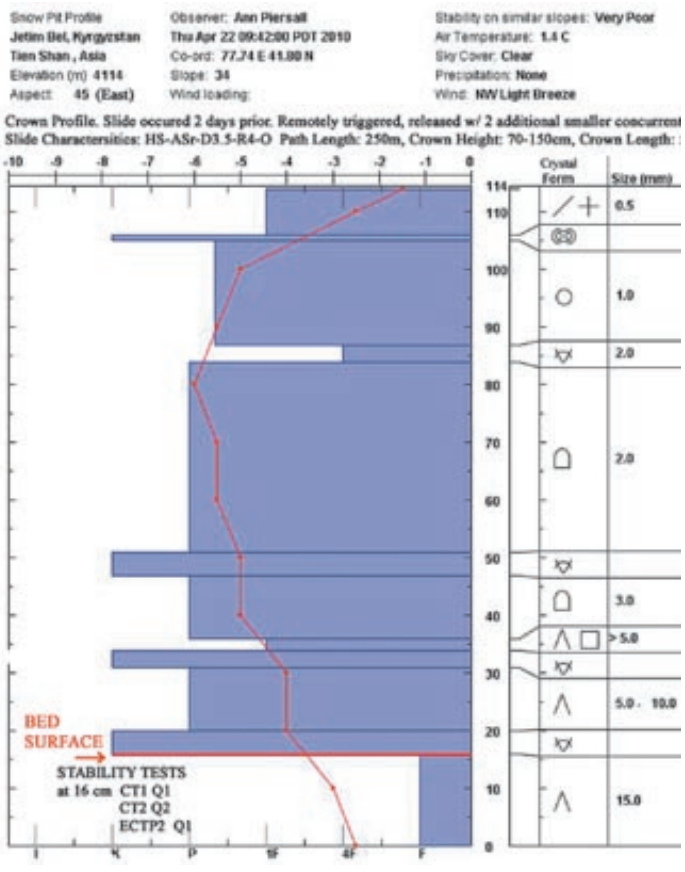
storm had dumped upwards of a meter of snow at high elevations across Central Asia. A widespread avalanche cycle ensued. The greatest effects were felt in Afghanistan, where over a dozen avalanches released onto the Salang Pass highway killing over 160 people and trapping several thousand more.

THE PROFESSIONALS

Another avalanche cycle occurred in March, closing all major roads for almost a week and trapping over 20,000 villagers along the Chinese border with Kyrgyzstan. During that time I was able to go into the field with the staff from the Kyrgyz National Hydro-Meteorological Office. Reaching our first avalanche slope I was informed that during the previous year one of the staff had been caught and partially buried in that exact spot. As they told me the story, everyone retrieved a long red string from their pack which they tied to themselves. I was reassured that this new safety technique worked "very, very well." If a person was buried, the string would float to the top, and you could simply follow the string to locate and extract the victim.

THE CLINCHER

In April, I was joined by two friends from Idaho for an exploratory ski-mountaineering expedition *(see "Caught with my Pants Down" on next page)*. Our trip was delayed by the violent overthrow of Kyrgyzstan's government immediately upon their arrival. A few days later we were safely in the mountains…that were blanketed by one of the most frightening snowpacks any of us had ever seen. Our hesitations about the snowpack were confirmed on one of our final days when we remotely triggered the slope above our camp. Horror – and the roar of snow that only stopped within an arm's throw of our tent – immediately vanquished any doubts I felt about the caution I exercised all winter.



A crown profile from the avalanche that came disconcertingly close to camp *(see photo, previous page)*.

BRINGING IT TO THE OTHER SIDE

By the end of my year in Kyrgyzstan, being foreign wasn't so foreign. I grew familiar with the uncertainty of a new place and new partners. Although my backcountry exploits often resulted in less than ideal situations, the collective experiences allowed me to construct an enhanced safety framework in addition to a wonderfully enhanced sense of humor. Navigation of a new physical and cultural landscape offered me great learning opportunities and an increased sense of self sufficiency.

My own stories aside, this reflection is not intended to generate unfair stereotypes. But the vast differences underlying avalanche-risk constructs and responses between Central Asia and the West cannot be ignored. In Kyrgyzstan, where the wildly continental climate results in persistent weak layers and high avalanche danger throughout the winter, personal and religious myths regarding the causes and timing of avalanches are widespread. Almost no avalanche education is available, and the idea of winter recreation is incomprehensible to most people. Avalanche deaths in North America are primarily limited to recreationists and avalanche professionals, the majority of whom are traveling in the backcountry. In Central Asia, most avalanche fatalities are civilians on roads and in villages. These deaths are in addition to extensive infrastructure damage incurred because vulnerable mountain villages and major transport routes cannot be easily relocated.

Obvious differences in socioeconomic circumstances are the most apparent reason that avalanche risk has not been widely addressed in developing countries such as Kyrgyzstan. While the Kyrgyz military does operate a basic blasting program on the country's main highway, closures and control work typically take place only after an avalanche cycle. With tight economic constraints, avalanche education and the development of preventative measures are hardly a national priority. However, with increasing worldwide interest and funding in risk reduction, the Western community may have future opportunities to assist with initiating snow-safety programs in developing mountain countries. Because the global avalanche community is dominated by Western practitioners and academics, implementing education and mitigation under different religious, cultural, and economic circumstances will require refining and reinventing tactics. While many people think of the future in terms of advances in the Western world, the future of snow safety may include diverse communities and will always be focused on returning to the basics.

Ann Piersall is from Kalispell, Montana, but home is wherever her skis are. From November 2009 through September 2010, Ann lived in Kyrgyzstan as a US Fulbright Student Scholar studying glacial retreat in the Tien Shan in addition to learning Kyrgyz and becoming a connoisseur of kymys, the traditional Kyrgyz drink of fermented mare's milk. This winter she will be a ski patroller at Alyeska Resort in Girdwood, Alaska. ❄

Editor's Note: Thanks to Drew Seessel of the Hans Saari Fund, who asked these grant recipients to contribute articles to *The Avalanche Review*: Ann Piersall and Courtney Phillips, at right.

A Trip to the Revelations

Story by Courtney Phillips

It can be hilarious what months of careful planning and weeks of meticulous packing inevitably lead to: four ski mountaineers standing next to a 600lb pile of the bare essentials and the lightest gear that technology has ever offered. And it's astonishing how that pile of gear, those four skiers, and one very large pilot can disappear into a small airplane. In reality, the deHaviland Beaver is not a small aircraft amongst the fleet of Alaskan bush planes, but compared to the commercial airliners that brought us to Alaska and the mountains that we'd soon fly between, it seemed tiny. Next to our 600lb pile of gear, it seemed downright diminutive. Nevertheless, we were soon airborne – headed for the very end of the Alaska Range and an obscure range called the Revelation Mountains.

The Revelations are incredibly remote and have hosted very few explorers since the first party ventured into them in 1967. The first traverse of the exterior of the range had been accomplished a few years earlier by Joe Stock and company; we would be the first skiers to explore the interior of the range. Our team was Andrew McLean, Noah Howell, Jim Harris, and Courtney Phillips.

Our plan to explore the Revelations was simple; ski as much as possible and eat as much as possible. The weather in the range is notorious for making it hard for human beings to live, much less skiers to thrive, so we tried to keep our expectations low. Rob Jones, a hunting outfitter who operates a lodge near the range, indicated that snow levels were about 60% of normal. We expected this to limit our climbing/skiing options, and we also expected that it would present risks beyond those we are normally accustomed to managing.

Our ride spent little more than 10 minutes on the snow; we began digging our first camp into the shallow show before the engine noise had completely faded down the glacier. As it turns out, the shallow snowpack became a critical factor in establishing our two base camps. Snow depth on the main glacier ranged from 6" to 36", where there was snow. The Revelation Glacier is old and fading, with large areas of exposed ice. Above us on all sides, couloirs split 6000' rock walls in the most dramatic fashion. Low snow or not, the Revelation Mountains present truly incredible ski-mountaineering terrain, easily measuring up to their name.

The risks of climbing and skiing in a range like the Revs are different from the ranges more commonly skied – different even from most of the Alaska Range. The most attractive lines ranged from 3000' to 5000' in relief, and all require direct ascent. Because of the variability in snowpack over that much relief, climbing up the couloirs of the Revelations can feel a bit like crawling into the barrel of the Missouri's 16" guns and hoping they're not loaded. Because the range had received so little snow during the winter, we could expect a thin pack over rocks to provide ample opportunities to trigger old slabs, and the difficult terrain management further compounded this. Granting some

confidence was the obvious fact that the area had received very little snow in the past couple weeks, granting time for instabilities to settle out.

Among the risks of being flushed out of a chute 4000' long and 40' wide, other risks were present. Most of the team's travel occurred on the main glacier that had very little crevassing, but nearly every day we were required to navigate fractured icefalls. Liberating even small amounts of snow on a 40-degree slope in these areas could launch a skier into inky dark crevasses below. Also, adding comedy and amazement to every day were the seracs that capped the walls of the gorge. One in particular, a well-loaded serac overhanging an El Cap-sized vertical wall, regularly launched tons of ice and rock that fell almost entirely freely to the glacier below. The event occurred every 12 hours or so, and shook the glacier impressively at our second basecamp over a mile away. Finally, the wild card in play was snow over water and alpine ice. At times we encountered faceted snow as much as 18" deep, laying in wait over ice that wouldn't need too much polishing to be fit for an NHL game.

At times, managing these risks was paramount, and at other times, unconsidered. Dodging the devastation under the seracs was relatively simple; don't go there, and don't camp there. The other risks were not so easily mitigated and in the end were eventually accepted. The team adopted the standard protocols of spacing out in the danger zones, skiing one at a time from safe spot to safe spot, and skiing through deposition zones as quickly as possible. Daytime heating encouraged us to avoid slopes that received prolonged direct sunlight – both to avoid being caught in frequent wet slides, and because the skiing in those areas wasn't terribly compelling. Frequently, within 50' of the tops of couloirs, hard snowdrifts were easily observed and avoided. Only once did I observe cracking while approaching these features. We received about 12" of snow in the only storm of the expedition. Other than a significant slide that cleaned out a chute we'd skied two days earlier, we observed very little natural activity after that.

In all, we found the terrain to require every attention we could give it, but the snow turned out to be relatively benign. We moved camp once; an all-day, four-mile epic of downhill trail breaking with skins on in heavy snow deposited by our only storm. We skied absolutely incredible lines, and we gave them names such as The Alpha Couloir, The Boot of All Evil, The Shroud of Turnin', Jesus Crust Super Gnar, and The Immaculate Deception. The walk out to meet our flight back to civilization included snow-covered glacier, bare glacier, moraine, frozen-river skiing, river bedrock, braided streams swelling with early spring melt water, and a shoe-sucking swamp. I recall that it was about 15 miles, but when you're having that much fun, who's counting?

Building on more than 15 years of climbing, cycling, and running, Courtney Phillips began skiing in 2006 and has since logged significant first descents in Utah and Alaska. He religiously avoids ski lifts, helicopters, and baggy pants, and he has never worn a shred napkin. Courtney was generously supported by an Exploration Grant from the Hans Saari Memorial Fund, for which he encourages all ambitious ski mountaineers to apply for early and often. ❄

The Revelations revealed. Between each sharp spire was a thin couloir like the barrel of a long, deadly gun. *Photo by Jim Harris*

Noah Howell and Andrew McLean climb high above second base camp. *Photo by Jim Harris*

Courtney Phillips and Andrew McLean managing vertigo. *Photo by Jim Harris*

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While the snow was not piling up in mid-winter as is typical in this maritime climate, there were however several noteworthy fair weather periods under high pressure that provided ideal conditions for extensive surface hoar growth. Noted surface hoar layers were formed around February 10, subsequently buried by light snowfall on February 13; the pattern repeated under high pressure February 18-23 with another layer buried February 24.

The most extensive avalanche activity on these buried hoar frost layers occurred in the North Washington Cascades where guides with North Cascade Heli-Skiing were being extremely cautious as numerous natural and triggered slides were occurring on these layers. It was also the buried surface hoar layer of February 24 that was a significant component to a very close call that occurred in the Crystal Mountain backcountry on February 28. A normally very cautious and predictably safe backcountry skier decided against his better judgment to make one last solo run in the late afternoon sunshine on a slope very familiar to him. He subsequently triggered a slab sitting on the surface hoar layer over a firm sliding surface. He was carried and wrapped around a tree mid-slope causing extensive injuries. Had it not been for his ability to get a cell phone call to the Crystal patrol it would surely have become a fatality. His recounting of the accident is available on the NWAC Web site under the Accidents tab and makes for compelling reading: highly encouraged.

While the typical winter weather in the Pacific Northwest arrived in late fall, it mostly skipped the actual winter months as a result of the El Niño conditions, only to re-emerge in spring. Beginning the last week in March the cool, wet spring continued even to this writing in late May *(see photo above)*! As an example, from March 25 through April 9, most areas along the west slopes of the Cascades received

Klawatti South Face avalanche, North Cascades National Park, May 5, 2010 *Photo by John Scurlock*

between 6-10' of snow! The NWAC weather station at the base of the Mt Baker ski area received 130" of snowfall during this 11-day period.

During the active spring, frequent winter-like storm-related avalanches occurred including more close calls. An avalanche-experienced party member in the backcountry near Snoqualmie Pass triggered, was caught, and seriously injured in a slide that released on an older layer, surprising the party. In another incident, two youthful snowboarders triggered a slide in the backcountry near Mission Ridge in early April, resulting in two partial burials and one injury.

A remarkable accident occurred on April 10 following this extensive storm cycle. A solo hiker on a trail was traversing the base of a large slide path below Granite Mountain just west of Snoqualmie Pass when snowboarders on the mountain above triggered a slide. The subsequent avalanche caught the hiker and completely buried him. He was able to get to his phone after a long struggle and got one call out to 911 telling dispatchers he was stranded, cold, and stuck before the phone battery failed. Not knowing the precise location, emergency and rescue workers made quick work to narrow the search zone based upon only two possible cell phone towers in the area. Helicopters and ground crews canvassed the Granite Mountain area before a dog team eventually located the victim four hours later. Thankfully he has made a complete recovery. Rather miraculous indeed!

—Kenny Kramer, NWAC forecaster