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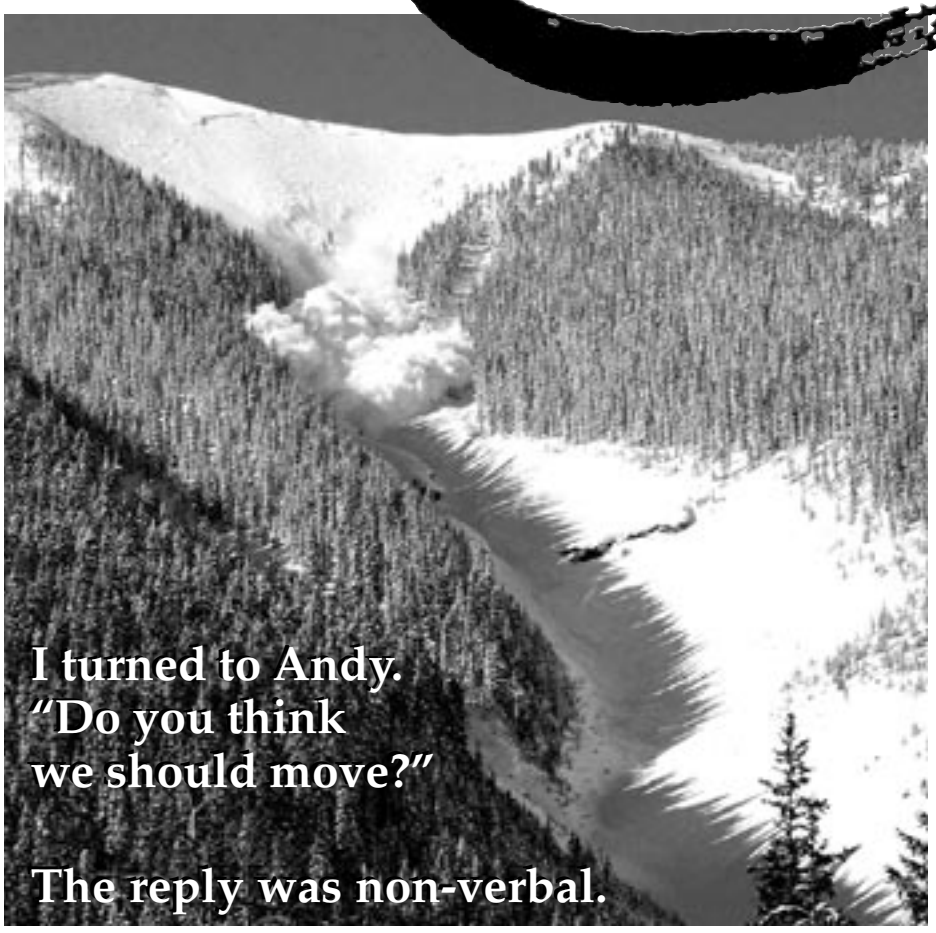

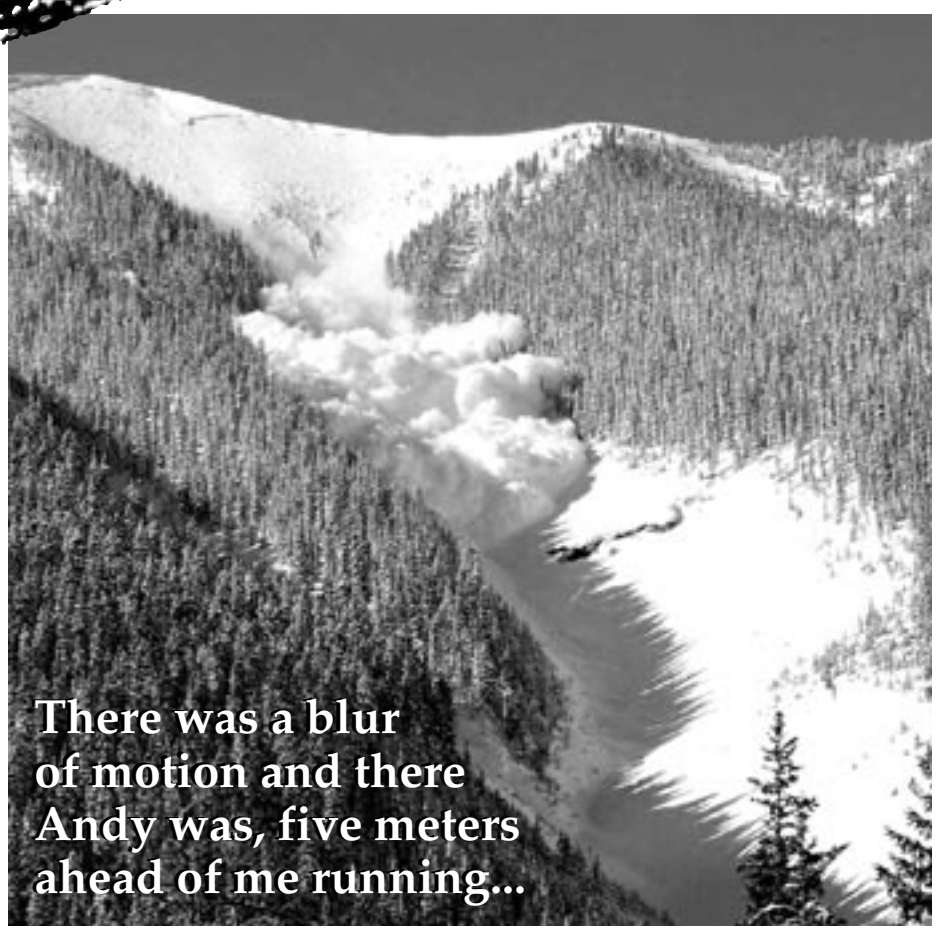

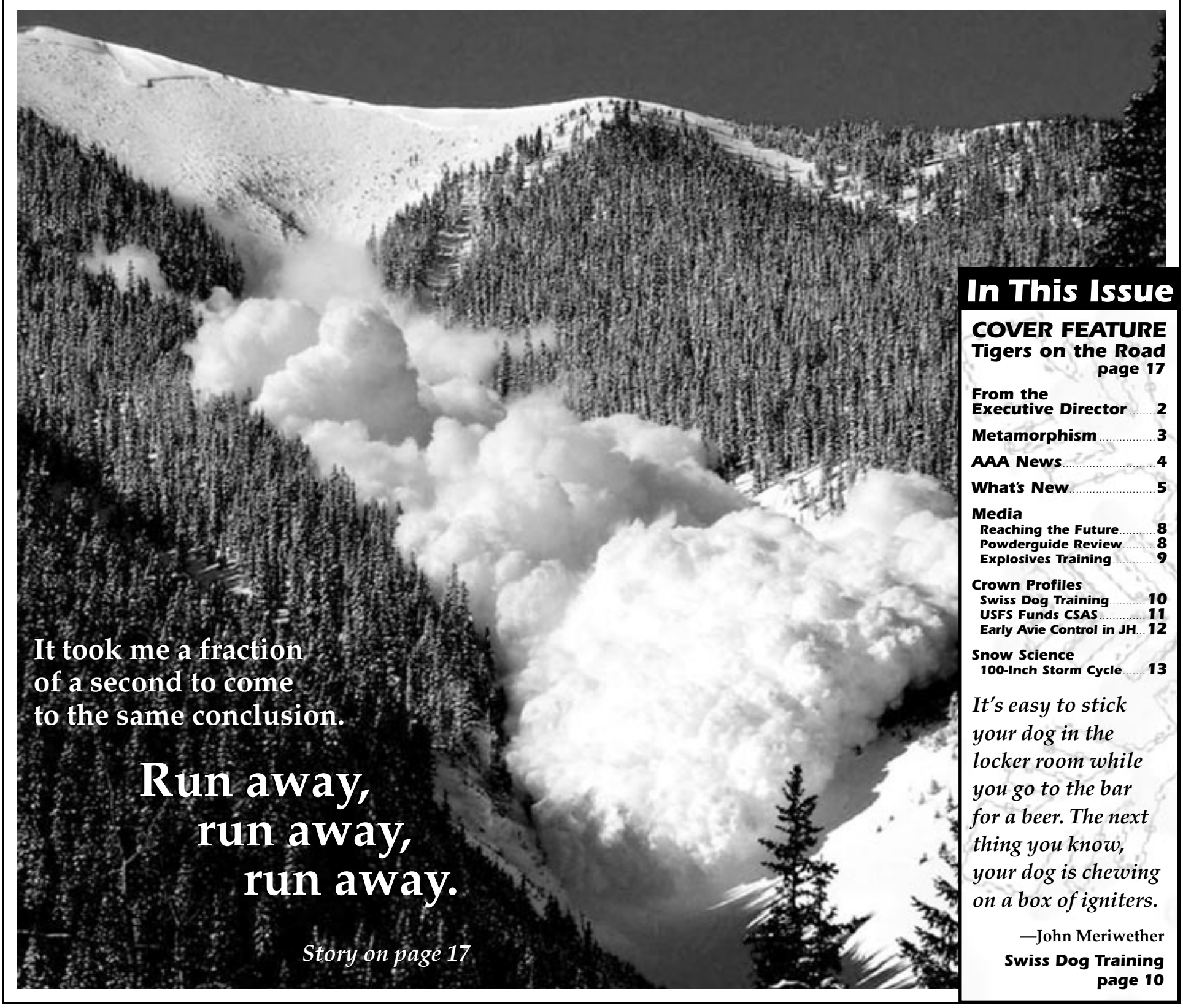

In This Issue

It's easy to stick your dog in the locker room while you go to the bar for a beer. The next thing you know, your dog is chewing on a box of igniters.

—John Meriwether

Swiss Dog Training page 10

THE Avalanche REVIEW

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Please send submissions to:

Blase Reardon — Co-Editor
636 Columbia Avenue
Whitefish, Montana 59937
tel: (406) 862-0812
work: (406) 888-7926
blase_reardon@usgs.gov
blase@cyberport.net

Lynne Wolfe — Co-Editor
PO Box 1135
Driggs, Idaho 83422
tel: (208) 709-4073
lwolfe@tetontel.com

Advertising:

Karen Russell — Fall Line Design
370 N 110 E
Driggs, Idaho 83422
tel: (208) 354-6500
fax: (208) 354-2213
karen@FallLineDesign.com

Business and Subscription Office:

Mark Mueller — AAA Executive Director
P.O.Box 2831
Pagosa Springs, CO 81147
aaa@avalanche.org
tel: (970) 946-0822
fax: (970) 731-2486

The American Avalanche Association

AAA

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 promote and act as a resource base for public awareness programs about avalanche hazards and safety measures;
F. To promote research and development in avalanche safety.

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

Layout & Design: Karen Russell, Fall Line Design, (208) 354-6500, karen@FallLineDesign.com.

FROM THE EXECUTIVE DIRECTOR: MARK MUELLER

Greetings from southwest Colorado! After several less than stellar winters here, this winter has been full of snow, avalanches, and great skiing. I hope the same goes for you and you are enjoying a safe, successful, and enjoyable winter.

With everyone's attention focused on their specific areas of concern, the Association keeps plugging along. Recent activities have been well documented in the pages of *The Avalanche Review*. My thanks to all those who have submitted material for the Review and spent much of their valuable and limited free time furthering the interests of all of us snow nerds. Much of the work of the Association outside the production of TAR is done by volunteer effort. This includes the Board of Directors. The AAA will hold elections this summer for many positions on the AAA Board, the Executive Committee and Section Representatives. Most of the current Board has devoted many years to steering the direction of AAA. I would like to encourage those of you who wish to become more involved in AAA to consider running for a position on the Board. Please contact me or any of the current Board if you are interested.

AAA is involved with more projects benefiting the avalanche community than ever before: the top-flight production of *The Avalanche Review*, creating a U.S. Observation Guidelines for weather, snow, and avalanches, and funding both academic and practitioner research to name a few. These efforts cost money and those funds come from your membership dues. As AAA expands its works and influence more demand is made upon those dues. I would like to ask you to assist in advancing our common goals by encouraging your friends, colleagues, and co-workers to become members of AAA. Our main product is *The Avalanche Review*, and if it would help to have some recent issues to pass around, let me know and I can send you some. An AAA member joins an internationally recognized association that is known for its dedication to high standards of professionalism, furthering the dissemination of avalanche safety information, and representing member interests to various governmental and private interests. Month by month and year by year our labors have continued to build an association whose efforts we can all be proud of.

Our Annual meeting will be held at ISSW 2004, in Jackson, Wyoming, September, 19-24, 2004. The first registration deadline has passed, but register before August 31, to take advantage of the most reasonable price. One can register online at www.issw.net. ISSW gets more popular each year, space is limited, and I encourage you to register as early as possible so that you will be assured a place at this amazing avalanche rendezvous.

As always, if you have any questions or concerns regarding AAA or your membership do not hesitate to contact me. I wish you all a great spring and summer and for those of you heading to the southern hemisphere or residing there a great winter as well.

Heard around the Pisco Bottle...

"Women are facets; men are rounds..."

Maria Solana Tristant
Brazilian avalanche forecaster from Portillo, interning with the CAIC in Silverton

The Avalanche Review: A Call for Submissions

- Seen any good avalanches lately?
- Got some gossip for the other snow nerds out there?
- Developing new tools or ideas?
- Learn something from an accident investigation?
- Send photos of a crown, of avalanche workers plowing roads, throwing bombs, teaching classes, or digging holes in the snow.
- Pass on some industry news.
- Tell us about a particularly tricky spot of terrain.

Write it up; send it to us. *The Avalanche Review* is only as good as the material you send. TAR is accepting articles, stories, queries, papers, photos. We can help if you're not sure how to write it up.

Editorial Submission Deadlines

Vol. 23, Issue 1 ..... August 1, 2004
Vol. 23, Issue 2 ..... October 15, 2004
Vol. 23, Issue 3 ..... December 15, 2004
Vol. 23, Issue 4 ..... February 15, 2005

Send text as .doc or .rtf files.
Send photos as grayscale .jpg files.

***The Avalanche Review* —**

Blase Reardon, co-editor
636 Columbia Ave.
Whitefish, MT 59937
(406) 862-0812
blase@cyberport.net

Lynne Wolfe, co-editor
PO Box 1135
Driggs, ID 83422
(208) 709-4073
lwolfe@tetontel.com

METAMORPHISM

Bridger Bowl Promotes Elliott to GM

By Doug Richmond

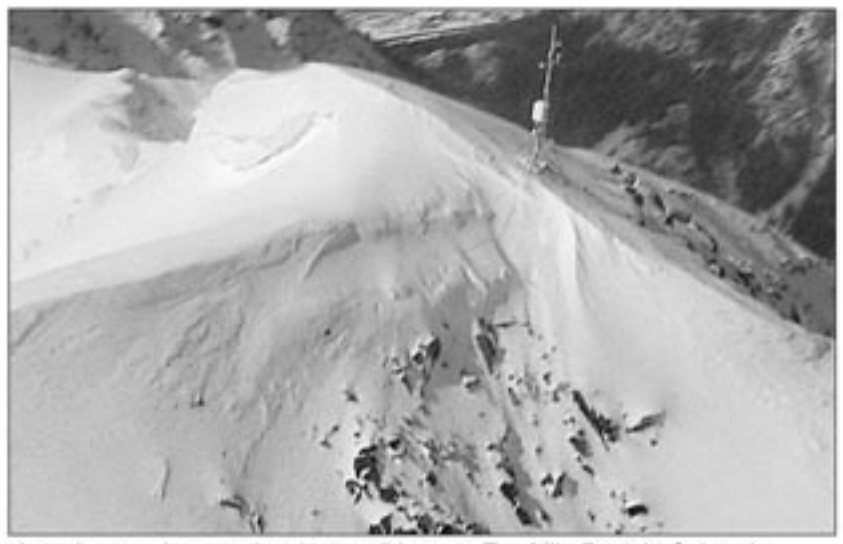
Bridger Bowl has promoted Randy Elliott from Mountain Manager to General Manager. The promotion is effective in June 2004. Elliott grew up skiing at Bridger Bowl and other Montana ski areas. He came to Bozeman in the 1970s as a Montana State University student and an accomplished skier. He started working at Bridger as a volunteer patroller in 1975 and Bridger hired him to help with avalanche control in 1977. Elliott joined the pro patrol in 1978, became Assistant Patrol Director in 1984 and Patrol Director in 1988. He has been Mountain Manager since 1991, yet has remained an important part of Bridger's ski patrol and avalanche control program, typically performing the work of two patrollers on storm days. Randy's leadership by example and his unparalleled abilities have helped everyone at Bridger. His promotion to General Manager is great news for all of us. One more thing that might help to put Randy's abilities in perspective: ski patrollers write songs about him.

Above:
Randy Elliott up close and personal
photo by Doug Wales

Right:
Randy Elliott in his office
photo by Doug Richmond

AAG Recognizes Birkeland

At its annual meeting in March, the Mountain Geography Specialty Group of the American Association of Geographers (AAG) awarded Karl Birkeland its "Outstanding Recent Accomplishment Award." The award was "for his work understanding the spatial and temporal distribution of snow avalanches in the Rocky Mountains." The citation noted that Birkeland "combines basic research and applications by getting into deep snow in the mountains. We could all wish for such a combination. His research publications on snow avalanches link fundamental processes and spatial and temporal distributions that make for exemplary physical geography. Mathematical and statistical analyses are combined with many days in the field… He is doing work of which we can be proud, as well as envious."The citation mentioned two of Birkeland's papers, one co-authored with Chris Landry.



AAA NEWS

Mr. Kazuo Fukuyama: 1934-2004

Story by Rand Decker

Photo by Daniel "Howie" Howlett

On February 14, 2004, Kazuo Fukuyama passed away. He was born in 1934 in Kumamoto, Japan, and first skied in his early twenties. After that, he was fascinated by snow and dedicated the next 50 years of his life to the snow and skiing.

He received the bachelor degree in Laws from Tokyo University in 1963 and then went to Europe to study German at the Goethe Institute, and to join the Austrian National Ski School of St. Christoph in Arlberg. The Austrian Ski School is known, to this day, for its commitment to mountain craft and guiding skills, as well as ski instruction. He spent two years finishing the ski-instructor's course in Austria. During these years, he also spent time in Paris and Grenoble learning French. He then joined French National Ski School in Chamonix and finished its courses in 1967.

After returning to Japan, Kazuo remained active in the Ski School of the Zao resort and as the Snow Safety advisor to the new Arai ski area in Japan. Kazuo was also instrumental in the Morita Sports Foundation, an organization founded by Mr. Akio Morita, the ex-CEO of Sony, to foster and support Asian winter Olympic athletes.

Kazou pioneered the use of North American-style avalanche forecast and control techniques to Japanese ski area operations. In that role, he brought numerous young colleagues to the USA to see Class A avalanche ski area operations first hand. He regularly attended the ISSWs and encouraged Japanese ski area operators to join the American Avalanche Association. He arranged numerous exchanges between North American avalanche professionals and their Japanese counterparts—including several over time to and from Alta Ski Lifts Company. In 2002, the American Avalanche Association awarded Kazou its Honorary Fellowship award.

In Memorium: Cal Tassinari

By Kim Corrette

Calvin Tassinari was an avalanche educator, a wilderness ranger, a photographer, a river runner, a dancer and much more. He was a professional with high expectations of all others. Cal led the first group of certified and trained professional ski patrollers at The Big Mountain in Whitefish Montana in 1960 and became the mountain manager in 1961. In the early 1970s, Cal taught the first avalanche education available to people in the Flathead Valley and northwest Montana. Among his students was Doug Abromeit, Director of the USFS National Avalanche Center. Class was held at the Flathead National Forest Office in Kalispell, Montana, recalled Art Sedlack, his longtime friend and colleague. Cal was still teaching to the local community in 2002 with his last class in Condon, MT. As a faculty affiliate for the School of Forestry, Recreation Program at the University of Montana, he co-instructed the CORE (Conservation and Outdoor Recreation/Education Program) program from the '70s to the '90s. The course included several overnight backcountry ski trips that focused on avalanche behavior, route selection, orienteering, leadership and group dynamics. Cal was a great teacher. I was one of the lucky students to participate in the CORE program.

Cal was born and raised in Cambridge, Massachusetts. He was an All-American high school hockey goalie and attended Northeastern University where he studied English Literature. After college he enrolled in the Air Force, teaching for the Survival School for Pilots. That was in Reno, Nevada, where he was also the ski patrol director of an all-women patrol. One of his many adventures was floating the Salmon River of Idaho from its start to finish, 450 miles in 45 days with no food. He and his companion carried a 16mm camera, a parachute, fish hooks, and a rubber raft. In the late '50s, he moved to Montana from Idaho to continue his work with the Forest Service. Working in the summers as a Wilderness Ranger and winters as a Snow Ranger, Cal was a pioneer in avalanche education and Wilderness management. The Big Mountain Resort ski patrol recently honored Tassinari with the designation of a new run called "Cal's Country." He dedicated his life to the study of snow and snow safety. "It is important to commend him for that," said Loren Kreck, a close friend and local conservationist. "Historically it is worth a lot, and he gave a lot to Big Mountain. He is just a good guy."

Photo by Bill Cunningham

WHAT'S NEW

Left: 6 to 11 foot fracture line of large avalanche (HS-AE-4O/G) triggered by Avalanche Guard in March 2003. Avalanche Guard box visible on righthand ridgeline.

Right: Craig Sterbenz holding spent dummy round in front of the single shot avalanche pipe. CIL-Orion Representative Adam Sly manning the pipe.

Below: The NW forecasters group at their annual get together just before test firing the avalanche pipe, Crystal Mountain, WA. March 15, 2004.

The Avalanche Pipe and Avalanche Guard:
an update on the Doppelmayr Blaster Boxes

Story and photos by Craig Sterbenz

Several years ago, the ski lift company Doppelmayr introduced the first "Blaster Boxes" to North America with two installations. I described development of the boxes in Volume 20 Number 4 (June 2002) of *The Avalanche Review*. The first installation was on Prospect Ridge in Telluride's ski area expansion terrain. The other installation was made for the Alaska Railroad Corporation in a very remote area between Anchorage and Whittier.

Telluride's "Box" was the prototype from Europe and was never constructed as a storage magazine. Therefore, it cannot be pre-loaded with rounds but must be loaded just prior to firing. Despite this limitation, it has proved to be a highly effective tool and an essential part of the ski areas control program. In March of 2003, it triggered a class four hard slab in the Westlake path. This avalanche was the largest there since March of 1995. This season (2003-4) it has triggered one class four and three class three slides on the same path.

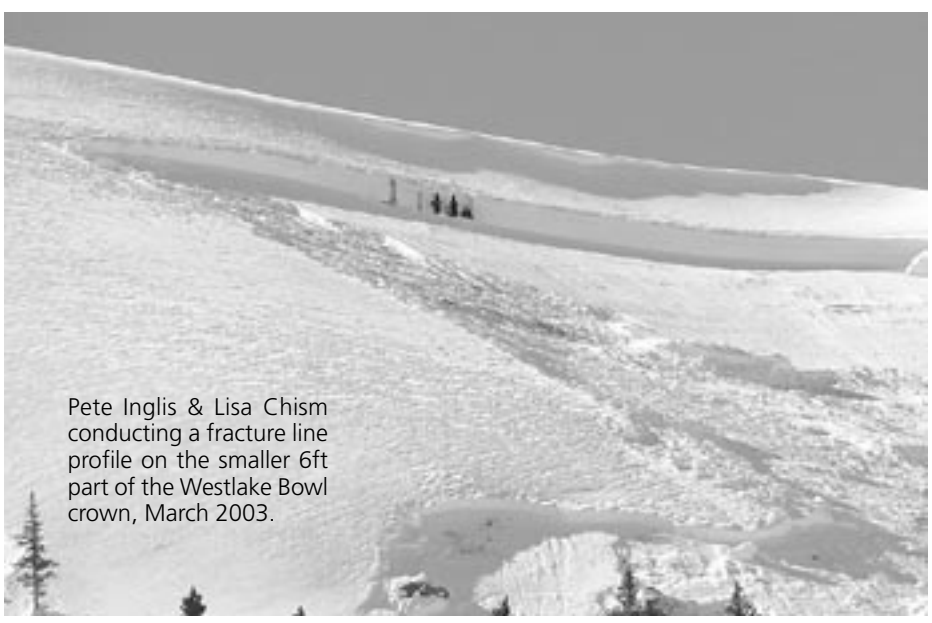
Alaska Railroad's four boxes had a few communication problems in the beginning due to the free-wave radio system provided by a third party. Once the radio problems were fixed, this installation has worked well with a number of large avalanches triggered by computer link from as far away as Reno, NV and Alta, UT.

Shortly after these installations were up and running, another company from Europe, Wyssen, developed their own remotely controlled explosive deployment system. The Wyssen "Avalanche Tower" was a revolving magazine hung on a tall inclined tower and designed to suspend a five-pound air-blast above the snow surface near the base of the tower. Once all the shots in the revolving magazine have been deployed, a helicopter lifts the empty magazine off the tower, reloads it on the ground and lifts it back onto the tower. Several of these towers were put in use to protect highways in Switzerland.

Doppelmayr, wanting to remain a ski lift company, transferred the "Blaster Box" program to a long-time partner, Inauen-Schätti. Oswald Graber, chief engineer for Inauen-Schätti, quickly changed the name from "Blaster Box" to the more politically correct "Avalanche Guard." In addition, Inauen-Schätti developed another version of the "Avalanche Guard" called the "Avalanche Master." The Avalanche Master was designed to compete with the Wyssen Avalanche Tower. Using small propulsion charges and tethers, the explosive rounds fired from the Avalanche Master can be suspended just above the snow surface in similar fashion to the Wyssen system. Unfortunately for Wyssen, its system suffered a major setback this spring. One of the Wyssen magazines underwent a mass detonation and exploded when being airlifted back onto the tower. Fortunately, the helicopter was using a longer than normal haul-line and was able to land safely even after shrapnel passed through the pilot's compartment.

One of the problems encountered during the initial installation of the Avalanche Guard boxes was availability of suitable explosive components. It was necessary to test a number of different explosives and other components. During this early period, the best performance was found using three two-pound cast boosters laced together with detonating cord and initiated with special cardboard pull-wire igniters manufactured by Martin & Shaft. Now aluminum crimp-on igniters and electric squibs are being imported from Europe.

The biggest improvement has come from CIL/Orion Explosives, which has worked closely with Inauen-Schätti and the local users to develop a poured round. The new Avalanche Guard round is cast using three kilograms of "Enviroprime," mostly composition "B" with some bacterial inoculants. This new round has a very fast detonation velocity of around 28,000 ft./second, and it will biodegrade if a misfire can't be found using an attached RECCO chip. These cast rounds also contain two plastic compression nuts, which firmly lock the cap-fuse assemblies into the cap wells.



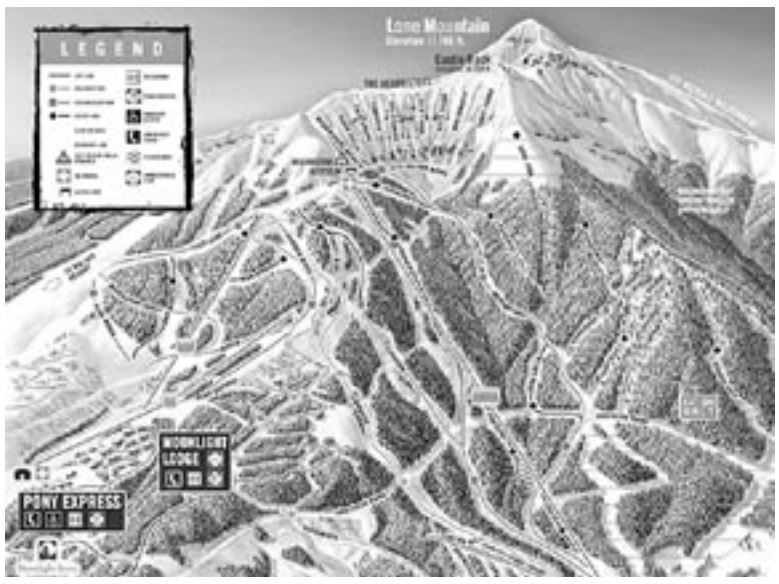
Pete Inglis & Lisa Chism conducting a fracture line profile on the smaller 6ft part of the Westlake Bowl crown, March 2003.

In addition to the "Avalanche Guard" and the "Avalanche Master," Inauen-Schätti began marketing of the "Avalanche Pipe." The Avalanche Pipe is a single-shot mortar tube which can be fired from a protected location using a traditional blasting machine like the "plunger box" used by Wylie Coyote in all the old Road Runner cartoons. The single-shot tube has the advantage of using propulsion charges of up to 60 grams of black powder, 150% of the 40-gram maximum charge used in the "Avalanche Guard." It also has the advantage of several elevations for the barrel and of being easily rotated up to 360 degrees to hit multiple targets. There are currently only two "Avalanche Pipes" in North America, one in Telluride and the other in Kicking Horse, British Columbia. Wyoming Department of Transportation has also installed a pair of "Avalanche Guard" 10 shot boxes on Teton Pass. See Volume 22, Issue 3 (Feb. 2004) of *The Avalanche Review* for more details on this installation.

Initial demonstrations of the "Pipe" took place in Crested Butte and Telluride during February 2004. The first day of testing in Telluride produced no avalanches, (hazard was minimal at the time), but one 60-gram shot flew horizontally an estimated 1,500 ft. Continued testing in Telluride during late February proved to be very successful. After repeated unproductive attempts to control Gold Hill #1 using an avalauncher, we brought in the Avalanche Pipe. One shot from the "Pipe" triggered a class four hard slab that filled the creek below with 30 feet of debris and lots of broken timber.

In mid-March, the "Pipe" took a road trip to Crystal Mountain, WA. The Northwest forecasters held their annual get-together there on March 15 and 16. The pipe was mounted to the bucket of a front-end loader and positioned in a lower parking lot for a demonstration firing. Since real poured rounds couldn't be shipped to Crystal with the pipe, two dummy rounds filled with plaster of paris were shipped down from British Columbia. The first round fired used 40 grams of black powder for the propulsion charge and brought cheers and applause from the crowd of onlookers as the round flew through the air. The next round was loaded with 60 grams of black powder and the anticipation level was high. Unfortunately the 60-gram charge proved to be too much for the brittle plaster of paris, and it simply disintegrated. Despite this disappointing result, the 40-gram shot was enough to show everyone there the great potential of the "Pipe." It can throw a 6.6-pound shot several football fields away; certainly farther than your best center-fielder can throw a 2 pounder.

Craig Sterbenz has worked as Snow Safety Director for Telluride Ski and Golf Company for longer than he can remember. He serves as Chair of the AAA Standards Committee. He also owns Snow Science Services. When he is not on snow, he likes to be surfing.



Lawsuit Filed Against Use of Avalauncher:

Boyne USA, Inc. versus Moonlight Basin Ranch, L.P.

By Don Bachman

Boyne USA, Inc.—owner of Big Sky Ski Resort, MT—has filed a lawsuit against neighboring Moonlight Basin Ranch (Ski Area) over the latter's use of an Avalauncher. Boyne's complaint document alleges, among other charges, that "Moonlight's use of the Avalauncher creates a hazard in that such use may result its duty of care to Boyne because shells launched from the Avalauncher that land on Boyne's property may cause injury or death to Boyne's employees or guests, damage to Boyne's property and/or infringement on Boyne's right to operate its property."

Moonlight conducts avalanche control by avalauncher on the "Headwaters Bowl," which rises above lift-served terrain that opened this season. The bowl is also a hiking route for accessing steep chutes which descend from the ridge line dividing the Moonlight property from Big Sky. The top terminal of the Big Sky Challenger Lift is perched on the east end of this ridge and is fenced off from the Moonlight Property.

Big Sky and Moonlight ski areas are private developments incrementally pieced together out of the checkerboard ownership pattern that once included public lands administered by the US Forest Service. Together, the two areas comprise an advertised 5,114 acres of ski terrain, which is a few dozen acres smaller than Vail. A gated private resort known as the Yellowstone Club borders Big Sky to the south. When its acreage is included, this complex of ski areas adds up to 7,114 acres, a total that surpasses that of the Whistler/Blackcomb complex in British Columbia and that makes it—by a scant 43 acres—the largest North American ski complex. All three entities have dedicated substantial additional acreage to real estate development.

The lawsuit has attracted considerable media attention from the local newspapers, ski industry publications, and the March 17, 2004 issue of the *Wall Street Journal*. That unlikely coverage—above the fold—contained some quotes from staff of each area explaining their position and the necessity for avalanche control. Taylor Middleton, GM of Big Sky states that "We don't like them shooting at us," while Lee Poole, co-owner of Moonlight states, "It's impossible, with all the systems we have in place, for anything to happen."

According to the WSJ article, "To prevent accidents, Moonlight…also calls Big Sky to warn of impending fire, then Big Sky clears lift attendants, patrollers and other employees from the area for a half hour or so until the bombing stops. Big Sky complains that this frequently causes it to miss its promised 9 am opening time."

Nevertheless, the fact that the Avalauncher, modified with safety bars to control the Avalauncher's aim, is oriented toward the ridge separating the two areas, has precipitated the charges in the lawsuit. Boyne charges (in part):

- Moonlight's use of the Avalauncher may result in intentional trespass because Moonlight is aware of the possibility that such use may cause shells to enter Boyne's property.
- Moonlight's planned use of the Avalauncher presents an imminent threat to the safety of Boyne's employees and guests.
- Moonlight's use of the Avalauncher… may be destructive to Boyne's property and Boynes's right to operate its property as a ski terrain, and/or may result in a continuing invasion of Boyne's property rights.

The complaint goes on to ask "that the Court permanently enjoin Moonlight from using the Avalauncher."

While the focus of the media coverage is on avalanche control, the litigation also complains about trespass, property damage, signs, gates, grooming, operations, adjacent real estate development and other elements of what was once thought to be settled in an agreement between the parties in 1964. At that time, it looked like there could be neighborly compatibility between the two areas, but that agreement has since been terminated.

Further complicating matters in this vast private ski area sprawl is Yellowstone Club owner Tim Blixeth's assertion that he owns the very summit of Lone Mountain, and plans to construct a lift to that point from his property to the south. Moonlight contests this claim, stating that they own the top of the mountain. Big Sky has already constructed a tram to within a few yards of the contested property, to serve the south face of Lone Mountain. The US Forest Service maintains that they conveyed the summit to Boyne during the privatization of the area. Resolution of this dispute through separate litigation has already begun.

These complaints, now in the legal system, involve active avalanche terrain and speak to the conduct of avalanche control activities and ski area operations. The avalanche community should pay attention to the deliberations and outcome of these actions, which may impact how other operational programs are established or conducted.

Search Training System Allows Remote Control

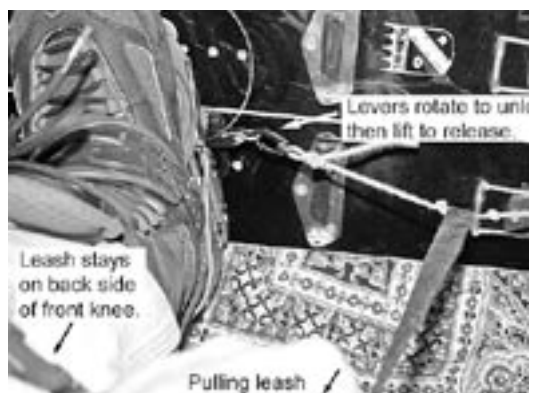
Ortovox introduces the world's first wireless transceiver training system to be marketed in the US. It will be available to patrols, snow safety schools and guide operations around the world. Ortovox's Search Training System allows one person to manage the entire search scenario and all variables from one portable control panel.

Set up your search area in minutes with a wireless system that allows you to create a search scenario without boundaries. Ortovox's STS allows testers to alter scenarios and variables all day long without wasting precious practice time digging up and relocating transmitting beacons.

Each scenario can be unique as the search coordinator isolates individual transmitters, alternating not only which of the 5 transmitters are on, but also the type of beacon and the burial orientation. Choose from 6 of the most common beacon model's signals throughout the day from the hand held remote. When setting up the course, create more variables using signal transmission angles from the diagram of a perpendicular flux line on each transmitter.

Another Snowboard Quick Release

By Bill Glude, Southeast Alaska Avalanche Center



Snowboards can be one of the best tools for riding out of a slide when you have to, but once you are caught, the big board with no release is like a button in a buttonhole. We have been using a ripcord style quick release modification to K2 Clicker snowboard bindings for six years now, with zero prerelease problems. It only works on pre-2003 bindings, because you cannot position the release levers on the inside of the newer anatomically shaped ones, but ski swaps, E-Bay, and consignment stores are good sources.

The first modification is to turn the locking release levers 90 degrees so they point at the frontside edge when locked, instead of at each other. Drive out their retaining pins with a punch, make sure the springs and washers inside don't pop out when you take them off, drill new holes at 90 degrees to the originals, and put them back together with a little Loctite on the pins so they don't come out. The 1/8" drill in our metric-impaired U.S. toolboxes is just a little oversize; 3 mm would probably be perfect. Turn them every so often as the Loctite hardens so any excess doesn't bind them.

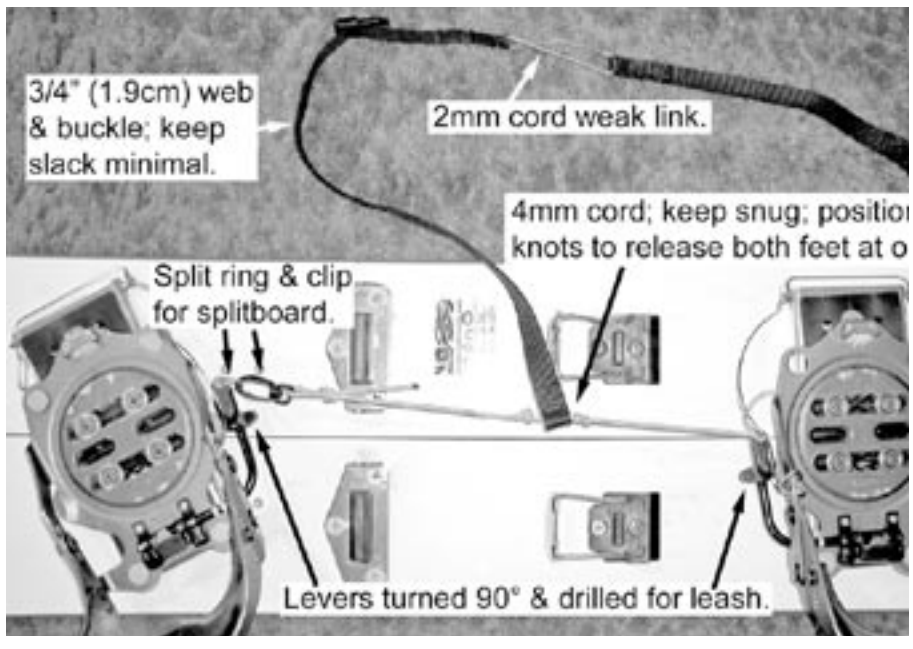
Drill a hole in the front of each locking lever that's just big enough for your release cord, and smooth the edges with a countersink.

Sew a piece of 3/4" (1.9 cm) flat nylon webbing for a leash to your front knee. Use 4 mm accessory cord running through a tightly sewn loop on the bottom to connect the release levers. Tie an overhand knot in the 4 mm cord on each side of the web and position it exactly where a pull releases both feet simultaneously. This is an important detail; one-sided release could break a leg!

The top of the leash has a simple Fastex type buckle closure and a loop of 2 mm cord in the part that encircles the knee, so there's a weak link to break when the whole thing needs to be jettisoned too quickly for operating the buckle.

Adjust two overhand knots on the ends of the 4 mm tie cord so they hold by jamming in the release lever holes. For splitboards, add a nylon clip and split ring on one end so it comes apart.

Rig the tie cord and leash so there's just enough slack for you to move. The keys to preventing snagged cords are to avoid excess slack and to buckle the leash so it is behind, rather than in front of, your leading knee.



Arc'teryx ISSW 2004 in Jackson Hole, WY

By Sue Muncaster

Come One! Come All! It's a 21st-century Mountain Man Rendezvous in Jackson Hole, Wyoming, September 19-24, 2004. Join other mountain men and women from around the world to meet old friends, show off your wares, check out the newest artillery, and—in the spirit of the Old West—have a rip-roaring good time at the Arc'teryx International Snow Science Workshop 2004.

Renowned for its steep terrain and world-class snow, Jackson Hole is the perfect venue for this biennial workshop dedicated to providing a forum for the exchange of current research and practical applications for avalanche hazard management. The area boasts three ski resorts, Grand Teton and Yellowstone National Parks, avalanche-prone highway corridors, helicopter skiing operations, and is a backcountry mecca for skiers, snowboarders, and snowmobilers. Oral and poster presentations throughout the week are chosen to support the theme *A Merging of Theory and Practice* to encourage partnership between snow scientists and avalanche practitioners. An industry-related tradeshow will offer the opportunity to check out all the latest technology.

The Arc'teryx ISSW 2004 includes two field trip options. The first is a tour of Jackson Hole Mountain Resort's avalanche mitigation program led by local ski patrol personnel. The second is visiting the Wyoming Department of Transportation's avalanche mitigation program on Teton Pass to observe the Gaz Ex installation, the newly installed Avalanche Guards, and the Infrasonic sensors. The trip will continue to an automated road-closure system on Highway 89 where 50 snow sails are installed.

On the lighter side, the Arc'teryx ISSW 2004 promises to be highly entertaining. A screening of Teton Gravity Research's latest ski flick Monday, September 20, will kick off the conference. Social hours hosted by event sponsors will keep the beer flowing and the grand finale is a gourmet Western dinner at the Mangy Moose followed by a slide show presentation by Grand Teton climbing ranger Renny Jackson, author of *A Climber's Guide to the Teton Range*. Don't forget about the climbing, hiking, mountain biking, fly-fishing, golf, whitewater rafting, and national parks that make Jackson Hole famous. Dining establishments, galleries, pubs and shops are plentiful and concurrent events include the Fall Arts Festival and Teton Wellness Festival.

The venue for the oral presentations is the Walk Festival Hall, home of the Grand Teton Music Festival, acclaimed for its intimacy and superb acoustics. Poster presentations, commercial exhibits, meetings, coffee breaks and parties will be held in adjacent buildings. Due to conference facility limitations, early registration is highly recommended. Fees are $215 per person for the week; the banquet is an additional cost of $40. There is no host hotel, but accommodation from camping to 5-star resorts is available in the immediate area. For more information on lodging, online registration, and details for presenters, exhibitors, and sponsors, check out **www.issw.net**.

Sue Muncaster has worked in the ski industry for over 20 years as an instructor, ski patroller and backcountry ski guide. She lives with her husband and 2-year-old daughter on the quiet side of the Tetons in Victor, Idaho. Sue is working hard along with a slew of other volunteers from the Jackson avalanche community to make the 2004 ISSW the most successful ever.

Highway & Land Mgmt Budgets Driven Down

By Dave Ream

Recent tax cuts and current world problems have forced lawmakers in Washington to get out the scissors and cut proposed spending on surface transportation and natural resource budgets.

Current House proposals show the surface transportation budget down a whopping 100 billion dollars to 275 billion over the next six-year budget cycle.

Senate and House committee figures differ somewhat but on March 17 the House Budget Committee chopped a huge 1.5 billion out of natural resource spending next year. Resource agencies' budgets like the Forest Service and Park Service operate on a one-year budget cycle so a 1.5 billion dollar cut is significant for each.

Even though the congressional budget places no direct limit on spending for individual appropriations bills, this provides a very potent indicator on where congressional spending is heading.

At this point we do not know what the final budget outcome is going to be but this is not good news for any State Highway, Park, or Forest Service avalanche forecaster.

Given that budgets for State Highway and Federal Land Management agencies are going down, we can hope that, proportionately, inevitable budget cuts for Avalanche Forecasting and Control programs are going to be small.

Revision of The International Classification for Seasonal Snow Cover on the Ground

By Ethan Green

The International Classification for Seasonal Snow on the Ground (Colbeck, S.C. and others, 1990) is now well accepted by most snow scientists and practitioners around the world. Besides the English version—which includes a French-German-Russian-Swedish glossary—Italian, Japanese and Slovenian translations are available too. However, some scientific communities (modellers, ecologists, biologists) hardly know the 1990 classification, and researchers and practitioners in important countries like India or Russia barely use it. Even snow scientists who rely on it feel some points of the existing classification need to be revised.

The International Commission of Snow and Ice (ICSI) has formed a working group to do just that. The effort will focus on the classification of wet snow and crusts. It may also consider issues relating to polar snow, blowing snow, snow in forests, and how well a non-specialist end-user may be able to use the classification. The revision may also include developments since 1990 e.g. from remote sensing (grain size), work on microstructure (e.g. the notion of bonds) or snow-cover modeling (e.g. colour codes for model outputs). Specialties like snow ecology, artificial—machine-made—snow or packed snow on roads may have to be considered too.

Charles Fierz (WSL Swiss Federal Institute for Snow and Avalanche Research SLF) is chairing the ICSI working group. The working group consists of two committees. The first is a technical committee of 6 or 7 people representing snow practitioners as well as snow scientists from various fields of research. The second is a "political" committee which will make the link to the wide range of potential users.

The aims of the working group are:

- to revise and adapt the 1990 classification to actual state-of-the-art, not including either perennial snow (firn) or snow in the atmosphere
- to promote an even more widely used and accepted snow classification, including efforts in translating the classification into other languages than nowadays available

At the same time, the working group will adhere to the main objective of the original document, which was to "set up a classification as the basic framework which may be expanded or contracted to suit the needs of any particular group ranging from scientists to skiers. It has also to be arranged so that many of the observations may be made either with the aid of simple instruments or, alternatively, by visual methods. Since the two methods are basically parallel, measurements and visual observations may be combined in various ways to obtain the degree of precision required in any particular class of work."

The technical committee will work out the revision of the actual classification. The political committee will circulate a final draft of the revised classification prior to final approval. The last stage will involve both committees and be devoted to the translation and the dissemination of the revised classification. The end goal will be to produce both a hard-copy English version (e.g. as a UNESCO Technical Document in Hydrology) as well as downloadable web versions (e.g. from the World Data Centre in Boulder), the latter including translations in various languages.

Field practitioners and scientists who are interested in suggesting changes to the current classification can contact the U.S. practitioner representative (Ethan Greene, greene@cnr.colostate.edu) or working group chair (Charles Fierz, fierz@slf.ch). The proposed revisions will be made available in the spring of 2005.

REFERENCE

Colbeck, S.C., E. Akitaya, R. Armstrong, H. Gubler, J. Lafeuille, K. Lied, D. McClung and E. Morris. 1990. *The international classification of seasonal snow on the ground*. Wallingford, Oxon, U.K., International Commission on Snow and Ice (ICSI), International Association of Scientific Hydrology.

MEDIA

How to Reach the Future Generation

By Steven Wiseman

> "We agreed that we need a broad mix of courses. In-depth courses should look at snow, not just as it pertains to avalanches, but as a broader topic."
>
> —*The Avalanche Review*, December 2003, Vol. 22 No. 2

At the fall continuing education seminar in Snowbird, an intriguing discussion about ways to improve avalanche education took place. After reading the summary in *The Avalanche Review*, I was struck by how approaching avalanche education from a different perspective is already addressing many of the stated issues. This perspective is focused on a decidedly less technical and less skiing- or riding-dependant population. Traditional avalanche education has not proven effective at reaching younger populations, and yet a perspective based on building a more broad understanding of avalanches as they relate to the natural world can successfully reach this audience. A broader perspective will reach the teenagers and future extreme skiers and riders before they are able to enroll in a Level 1 class, and as they are beginning to explore the world around them. As agreed upon in Snowbird, reaching this demographic will lead to a more avalanche savvy public in the future.

As many teachers will tell you, an invaluable part of a successful lesson is a good introduction. The introduction forms the base of knowledge and makes first mention of subjects that may be discussed later. Introductions also tend to be broad and less detailed than the lesson to follow. Introductions are an overview and helps paint a big picture to form a frame of context for more detailed information.

For young students or those without much winter backcountry experience, a broad introduction into avalanche topics can provide the base and context. Without an introduction, many students have no way to process the technical and skill oriented material in a traditional Level 1 class. For many, avalanches are mystical happenings that occur way out in the far reaches of the mountains, or only during extreme weather cycles. Our challenge as educators is to take this unfamiliar creature and make it familiar, and do so in a very short amount of time.

One way to encourage familiarity is to relate avalanches to other things that may be more familiar or easier to understand. After all, an avalanche does not exist separately from the world around it. Yet it is very hard to teach about avalanches when students have never had any previous exposure to avalanches or avalanche terrain. Think about it—how many students in your last level 1 class had little or no backcountry experience? Probably many of them. We expect this because we want students to have knowledge before venturing out into the backcountry. But this lack of experience means many students have no introduction, and no basis of understanding.

A great example of providing the necessary introduction is being demonstrated by a nonprofit environmental education school operating at the base of the continental divide in Red Cliff, CO.

Part of the stated mission of the Gore Range Natural Science School (GRNSS) is to raise environmental awareness and inspire stewardship. Avalanches are included in the curriculum due to their role in the overall ecology of the area. Many students know of avalanches, know they occur in nearby areas, but only know of them as hazards to the backcountry traveler.

Middle school students explore the variable Colorado snowpack outside of Red Cliff.

Photos by GNRSS staff

The GRNSS approaches avalanches by including them as a topic in a larger examination of the natural world. This approach makes the sometimes complex science much more digestible and contributes to the idea that avalanches aren't simply something to avoid; they are part of the winter environment and can be studied, predicted, and observed as a part of the environment. A recent 8th grade student from Gypsum Creek Middle School had this to say: "The most memorable thing I learned about the mountain environment where I live is that avalanches can happen."

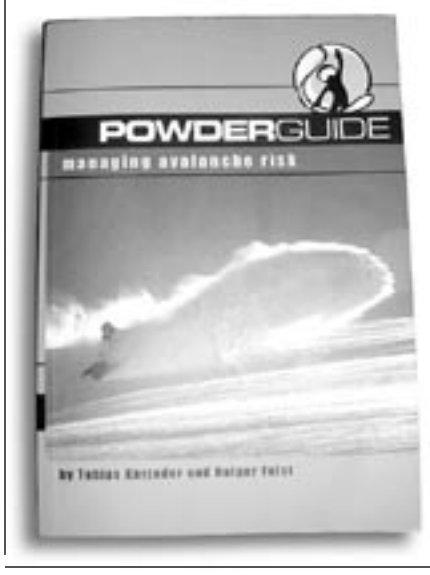
Each winter, GRNSS naturalists bring the elements of snow science to nearly 200 local 3-10th grade students, and have been doing so for over six years. In a typical snow science class, GRNSS educators introduce concepts like the avalanche triangle, risk factors, and safety tests, while making scientific observations of snow depth, snow density, layering, crystal types, and temperature gradient. All of this is done through cooperation with local schools in the Vail area and incorporating the school's existing science curriculum. "It is important for people who live in mountain communities to know the risks and dangers of winter backcountry travel," said Noel Falk, an 8th grade teacher.

In addition to snow science, the GRNSS curriculum mixes winter tree and shrub identification, animal track identification, a basic weather-pattern discussion, and often a mediation or discussion about local issues affected by the snowpack. Adding these topics to learning about snow science gives students something to relate it to. It is real and tangible and most of all, present. Avalanches, or avalanche terrain, may or may not be accessible and so learning about such areas can be tough. Learning about how avalanches are a part of the larger-scale winter environment is easy when the larger-scale winter environment is right in front of you.

Steven Wiseman is the former Interpretive Programs Coordinator at GRNSS where he did as much teaching and skiing as possible while helping increase awareness and inspire stewardship of outdoor areas for students of all ages. You can reach him at his new home in Golden at rydfattire@yahoo.com.

BOOK REVIEW

Powderguide: managing avalanche risk



Powderguide is a new addition to the avalanche bookshelf. It is a basic avalanche text written by several young German freeriders. What makes it of special interest to many in North America is its inclusion of the first complete English translation of Werner Münter's, *3x3 Filter and Reduction Methods*. Complete in the sense that the basis of the methods is explained as well as how Münter has intended the methods to be used. Other recent translations have been incomplete and/or inaccurate.

The authors discuss safe skiing and riding strategies as well as spatial variability and the limitations of snow pits and stability tests in decision-making. They do not introduce pit techniques and test procedures. The authors consistently use a cautionary tone in the text and encourage readers to take a multi-day avalanche course to complement the information they present.

Along with basic information about weather, snow, avalanches, and rescue, this 192-page book contains a broad spectrum of information that includes chapters on freeriding equipment (more than just beacon, shovel, and probe), first aid, and specific topics such as map reading, environmental ethics, and the use of snowmobiles to name a few. An extensive resources section rounds out the contents. The book is sturdy, visually pleasing, and contains numerous color photos from around the globe.

The book covers a lot of ground and contains plenty of practical information especially for novice backcountry users tempted by what they call, "the white rush." The translation is excellent and contains few unusual expressions. I encourage you to check this new book out, especially if you have an interest in Münter's methods. —Mark Mueller

Powderguide: managing avalanche risk. By Tobias Kurzeder, Holger Feist, Patrick Reimann, and Peter Oster. Translation by Stefan Österreicher. Boulder, CO, Mountain Sports Press, 2003. ISBN 0-9724827-3-3.

Editor's note: Powderguide presents a first-generation version of Münter's Reduction Method. Münter's later versions have, among other revisions, added a "golden rule" and "Decision Matrix," applications of the method that don't require users to do any math.

AAA Partners with CAA, NSAA, and USFS to produce Avalanche Blasting Resource Guide

Story by Woody Sherwood • Photo by Doug Richmond

Presentation Overview

- Review of the core subjects applicable to hand charging
- Overview of hand charging
- Preparation of cap and fuse assembly
- Assembly of hand charges
- Transport, area closure and communications
- Site procedures
- Misfire procedures
- No-light procedures
- Workshop

THE BASICS

- Importance of explosives training
- Avalanches
- Applying explosives
- Assembly of hand charges
- Regulations and guidelines
- Definitions
- Personnel
- Communications
- Transportation

STORAGE OF EXPLOSIVES

- The Safe Explosives Act and Storage Regulations
- Typical magazine features
- The types of magazines
- Storage practices
- Storage compatibility
- Magazine protection
- Signs

PowerPoint slides present highlights of the resource guide and an overview of the program.

The American Avalanche Association is proud to be a sponsoring entity in the recently released *Avalanche Blasting Resource Guide*. This Resource Guide is the culmination of many years and countless hours of work by many people. This program is intended to be a living resource guide, tailored to the individual requirements of each individual operation. Professional members of the AAA and the National Ski Areas Association (NSAA) may purchase the resource guide. The NSAA is handling the administrative task of selling the guide: Kate Powers, (720) 963-4209, katep@nsaa.org. The price of $400 includes a PowerPoint presentation, instructor's guide, and attendee handout.

The resource guide is licensed through the Canadian Avalanche Association (CAA), and we are under strict licensing agreements with our partners regarding unauthorized duplication of the material. We owe an extreme debt of gratitude to the Explosives Committee of the CAA, the Membership of the CAA, and Claire and Evan of the Executive Staff for making the guide available to us. They have assured us that the funding from the licensing agreements for the resource guide will be used to further intellectual property that will benefit the Canadian and American avalanche communities. The NSAA has been a tireless sponsor of our efforts and we owe many thanks to Geraldine Link and Tim White for their efforts. The US Forest Service has been a constant supporter and provided a generous financial contribution to assist us; our gratitude goes to Ed Ryberg and Doug Abromeit for their unwavering support. Larry Heywood and the NSAA Explosives Committee should also be thanked for their support and encouragement as the concept for this program became reality. Bill Williamson, Corky Ward, Doug Richmond, Steve "Piney" Gilman, Larry Heywood, and G. L. "Woody" Sherwood spent several days locked into a conference room at Jackson making the necessary changes to the CAA program, modifying it to our nomenclature and procedures; they deserve the big credit for turning this concept into reality.

The process of developing the *Avalanche Blasting Resource Guide* began with the formulation of NSAA Guidelines for Explosives Use In Avalanche Control. We subsequently had several meetings of Avalanche Professionals from North America, IME, ISEE, and several regulators to address the issues that surround explosive use in avalanche hazard mitigation. This resource guide, promoting consistency in use and training, is the tangible evidence of our commitment to industry professionals.

Patroller Kevin Mundy blasts upper Tight Squeeze at Bridger on 2/11/03, the day after a shot in the north bowl formed a 7-ft crown. The shot in the photo is 2 or 3 cast boosters (probably 3 for 6 lbs).

The resource guide is designed to be flexible to each organization's individual needs within the context of the NSAA Guidelines for Explosives Use In Avalanche Control and Federal, State and Local Regulations. We suggest that each organization develop a digital image file of their individual facilities and procedures to assist with presenting the resource guide. It is currently available as three modules that come as one package: Core Training, Hand Charging, and Cornice Blasting. The program is designed to be used as a training progression through the modules.

The Canadian program also has Avalauncher and Helicopter Deployment modules; we are in the process of approaching the Avalanche Artillery Users of North America for assistance in developing the Avalauncher Module. At this time we are assessing the need for the Helicopter Deployment module. Please contact me with your perception of that need and your availability to help with the transition of the materials to our nomenclature and regulations.

Woody Sherwood is Patrol Director at Crested Butte. Contact him with your input and ideas at wsherwood@cbmr.com.

Avalanche Beacon Developed for Fire Rescue

Ortovox is bringing over 20 years of research, development and expertise in search and rescue technology to the fire rescue world. With minimal training, Ortovox's rescue beacons can quickly become a critical part of a rescue when things take a turn for the worse by helping to locate a missing team member within a structure. Rapid Intervention Teams use beacons in search mode to pinpoint the firefighter transmitting a signal within the building, using distance and direction readings.

"Our reputation in the snow safety world is that of a company providing reliable, durable equipment with some of the longest range capabilities in the industry," says Marcus Peterson, General Manager of Ortovox USA. "Ortovox saw a place where our existing technology can help to save even more lives and is working with top firefighting professionals and trainers across the country to build equipment tailored to their specific needs."

Ortovox beacons allow search teams to quickly find the distance and direction of a victim within a structure when minutes determine life or death. A firefighter or emergency worker can be located through a combined analog and digital signal transmitted from the beacon, in conjunction with personal alarm safety systems. In testing situations, Ortovox beacons found victims through reinforced concrete, smoke and heat.

"The impact of Ortovox's technology on rescuing firefighters, especially in urban situations such as earthquakes, wildland fires and large scale structural and industrial fires as well as metropolitan situations is enormous," says Tom Connors, a training/safety officer. "The use of an Ortovox beacon cuts search time by half or less may potentially saving 30 lives or more every year. Of the 75-125 firefighters who die each year, many are lost in large structures and found too late."

Connors continues, "The beacons are going to revolutionize the fire service and make it safer for firefighters to do their jobs." Connors is an expert in structural, wildland urban interface fires, Rapid Intervention Crews as well as highrise fires. He has been a fire professional for decades and is familiar with snow safety gear from a side career as a ski patroller at Snow Summit in California.

CROWN PROFILES

Stevens Pass Adopts Swiss Training for Avalanche Dog Program

By John Meriwether

The avalanche dog rescue program here at Stevens Pass has had a good kick in the butt thanks to the Swiss and their willingness to share their amazing avalanche rescue dog-training program. In evaluating our dog program here at Stevens Pass, I started looking into the usual how, what, where, and who's who in the dog world. I also looked back into the archive of *The Avalanche Review* and found that there really wasn't a whole lot of info on dog rescue programs. I wrote this article to do two things: the first is to inform folks of what we have learned and how it has affected our dog program, and the second is to spark some national dialog on avalanche rescue, dogs, and standards. As you will find out as you read on, we have embraced the Swiss technique for training our dogs. This year I had the great honor in traveling to Switzerland to train and observe their program. I would have to argue that the Switzerland dog training progression, certification program, and national response program, are the best that I have every seen.

The cavalry's coming!
The cavalry's coming!

View from inside after successful find. *Photo by Christian Perret*

Stevens Pass basic dog stuff

Until recently, the dog program at Stevens Pass has been a bit sluggish in its development. We've had a dog program here for the past 15 years averaging 1-3 dogs at a time, an easily managed number. However, the program has grown from three to seven dogs in the last three years. Where did all these dogs come from? We now find ourselves managing seven new dogs/puppies and six new handlers. With new dogs comes new, and in our case, inexperienced handlers. Seven dogs/puppies running around at once definitely make morning meetings active and noisy. With all these additions, we needed to take a hard look at and get serious about our dog program.

We considered three very important things initially:

1) Maintaining control at all times.
2) The difference between puppies and dogs.
3) How to ski with your dog.

Management: what do we expect of the dogs and the handlers to insure that the dogs don't drive everyone nuts? The dogs must be contained or supervised at all times, which is easier said than done. It's easy to stick your dog in the locker room while you go to the bar for a beer. The next thing you know, your dog is chewing on a box of igniters. This didn't really happen, but you could imagine! We now require that all patrol dogs be crate trained, tied up and/or supervised at all times. You can't just throw your dog in the top shack/locker room and expect someone else to watch over it. This rule goes for all dogs everywhere on the mountain.

Puppies! Obviously puppies have different needs than adult dogs. What do you do with these things if they can't do "grown up things?" It's a common belief that running a dog in the early stages of development can damage their joints. I have asked many vets about this idea. They have all recommended not running the dogs until fully grown. Once the growth plates dissolve the long bones should be ready to take "normal" stress. If the dog runs with constant beating—like that in bike rides, jogging, or running down a groomed run—before the growth plates are dissolved, the dog has a very high potential of having joint problems later in life. One vet gave the example of jumping out of a pickup truck (how about a chair lift?)—very bad on the young joints. However, most vets said that once the dog is fully grown, which is 1-2 years depending on the breed, they should be good to go. Ok, no running for the first year. Even when the dog is 40 pounds at 8 months? Humm? Because I went through an entire season carrying my dog everywhere, I take great pleasure in scolding a new dog handler when they run their puppies.

Dogs and handlers training in Switzerland. Stevens Pass rescue dog Stanley and handler/ Stevens Pass patroller Ryan Forbes in the foreground. *Photo by Christian Perret*

There is a fine line between developing your dog physically and running them into early retirement.

What about dogs on the slope running, riding, and just participating in the day-to-day travel? It's a bit unnerving to see a free-running dog dodging those 20,000 edges. "Yeah it's a nice doggy, kid, but get any closer with those edges and I will pull your ticket." Most of our dogs have the signature leg scars, mostly caused by their owners skiing too close. These accidents seem to be a rite of passage for ski area avalanche rescue dogs.

We've found three skiing methods to maintain control of your dog on the slopes: "center heel" (running the dog between your legs while in a wedge), "out front" (the dog running directly in front of you), or heel right/left. The wedge technique does have its risks. If you need to stop fast or turn to avoid something, the dog is very close to your ski edge and can get cut. My dog earned his rite of passage from this technique. I still run my dog center heel but very slowly; slow enough to stop instantly in a wedge. When going fast down an open slope I prefer to have my dog out front. This technique has the advantage of allowing you to know what your dog is doing at all time. You can see potential risky interaction and react before it happens. When the dog is behind me, I get nervous when the public wants to get close to the dog.

It's a simple fact that it's risky for dogs working at any ski area. It's dangerous for the dogs to be interacting with thousands of skiers and snowboarders, as well as physically demanding on the dogs and the handlers. Common working dogs such as sled dogs, disaster dogs, and herders have less than a 10-year working life.

The dog's life work—Searching

Hundreds of questions came up when we started thinking about the nuts and bolts of training the dogs to search for people buried in avalanches. A few of these are:

- Are we doing things the right way?
- How do other programs train and operate?
- How many people should a good experienced dog be able to find, and how long should it take?
- How long should it take a dog to learn how to search?
- When are they ready to take on a real mission?
- Who is reputed to have a good dog program?

We took a look at some of the common programs: CARDA, the Lake Tahoe areas, and the Colorado ski areas. Then we stumbled on what has turned out to be, arguably, the best alpine search program in the world: the Swiss. The country of Switzerland seems to do everything right: chocolate, knives, cheese, and even alpine rescue. It turns out that Switzerland was the first to train dogs for disaster searching, both urban and wilderness/avalanche. They are well known throughout the world for great urban rescue dogs, and now it turns out that their avalanche rescue dogs are top notch as well, which makes sense for a country surrounded by the avalanche prone Alps. During the winter of 2002/2003, the country of Switzerland had 8 live recoveries out of 47 real missions. All found by dogs.

The rescue learning curve

During the winter of 2001-02, one of our patrollers attended a Level 1 Swiss dog course at Lost Trail Powder Mountain in Montana. Last year (winter 2002-03), myself and another patroller attended the same Level 1 class with our new dogs. The instructors invited us to Switzerland to attend their Level 2 class, which we had the great honor of attending this winter (February 2004) in Andermatt Switzerland.

Not only did we complete the level 2 course, we were also were able to watch several dogs test for their annual certification (Level 3). Once a dog and their handler pass the Level 3 exam, they are required to take the exam every year to maintain their status.

I was very impressed by the method the Swiss use to train their dogs: it simply makes sense. The method also proved itself over and over as we watched their top dogs flawlessly search a 300 x 300 meter debris zone and find 4 people and 2-3 backpacks within 30 minutes or less. The backpacks' weak scent represents

GOD spelled backward. *Photo by Aimee Forbes*

dead people (the great dogs always found the live people before the dead ones). They have an hour to complete the test but most were done well under the time allowed. A dog and their handler are given three to five years to reach Level 3.

The end result is that a "certified" dog should be able to find multiple victims as well as a few backpacks buried 2-5 meters deep within an hour. The Swiss also have the usual handler awareness and skills tests that include knowledge of avalanche mechanics and rescue techniques (probing, transceivers, medical, etc.). A good dog handler must be able to do a transceiver search and run their dog at the same time.

You have probable figured out by now that we have adopted the Swiss method of training avalanche rescue dogs. I am really sold on the method: it just makes sense in every aspect of avalanche rescue. With any luck next year we may have our dogs Swiss certified.

The Swiss progression

Puppies between the ages of 7 weeks and 7-8 months learn the standard commands of sit, come, stay, and heel, while acclimatizing to life at a ski area (crowds, chair lifts, snowmobiles). By the end their first season they are doing very simple runs, always with their handlers.

The second season the dogs are trained in the Swiss 4 phase progression. Below is an outline of this progression to open dialog on the training and what we do.

Preparation: It may sound simple and straight forward, but there is a lot to digging a good hole for dog training, including ways to make the digging easy and very effective at the same time. The holes should be big enough to comfortably fit 2 people and a dog inside. You should be able to reward and praise the dog inside the hole. Yes, the holes are big. The hole should be covered with blocks of snow (avalanche debris), and they should be reusable without having to "clean" out the hole after every use.

Phase 1: The instructor restrains the dog. The handler gets the attention of the dog and moves to the prepared hole while calling the dog. Then the handler hides in the hole. The instructor gives the dog a search command and lets it go. As soon as the dog finds the handler, the handler rewards and praises it. The Swiss use food for the reward. The dog is leashed, and the team returns to the starting point where the handler turns the dog over to the instructor.

Phase 2: Again the handler gets the dog's attention and moves to the prepared hole while calling the dog. This time a shoveler goes along to bury the handler with blocks of snow in front of the entrance and then returns behind the instructor. The instructor gives the dog the search command and lets it go. At the burial spot, the dog is expected to alert by digging at the hole. The dog is expected dig and go all the way into the hole without help.

Phase 3: This phase uses an additional subject. The shoveler, the handler, and the additional helper walk to the hole. The handler gets the dog's attention by calling him. The handler is then buried in the hole with and behind the subject. The shoveler returns behind the ready dog. The instructor sends the dog to search. Again the dog needs to dig well, going all the way into the hole where the helper—not the handler—rewards it.

Phase 4: The final phase is when the handler starts the dog. A victim and a shoveler walks to the hole, the victim turns and gets the dog's attention by calling its name before getting into the hole. The shoveler blocks up the entrance and returns to the ready dog. The handler releases the dog to search.

Continued next page ➡

Forest Service Funding Boosts Center for Snow and Avalanche Studies

By Chris Landry

One of Silverton, Colorado's newest "enterprises," the Center for Snow and Avalanche Studies (CSAS), has reached an important milestone on its quest to establish a field-based venue for American snow science in the heart of the San Juan Mountains. The CSAS's first funding came from the American Avalanche Association—$2,000 in seed money. A little over a year later, through the efforts of Colorado's Senator Ben Nighthorse Campbell, this emerging snow system science and education organization has been awarded a $75,000 US Forest Service "Rural Development, Forestry and Communities Program" grant. Those community development funds were requested on behalf of the CSAS by the Mountain Studies Institute, the CSAS's sister organization in mountain system education and research in Silverton, a community struggling to develop a new economy following the collapse of hard-rock mining a decade ago.

"We are particularly gratified and honored to receive this timely funding from the Forest Service," said CSAS President Don Bachman, formerly the lead avalanche forecaster for Highway 550 in Silverton, and later the Director of the American Avalanche Association. He added, "The Forest Service kick-started American avalanche science and practice in Alta in the '50s. Now, combining these $75,000 with the some $85,000 in 'bootstrap' cash and in-kind investments made by the American Avalanche Association and our peers in snow science and practice, and by the Janss Family Foundation, our Board of Directors, and our staff, we are poised to firmly establish a 21st-century national snow science asset. And, we're proud to accept these funds on behalf of the Silverton community, which has an important history of contribution to American avalanche science and lore."

Founded in January, 2003, the CSAS has Silverton roots extending back 30 years, to the "INSTAAR San Juan Project" of the 1970s, funded by the Division of Atmospheric Water Resources Management of the U.S. Bureau of Reclamation. Bachman was the first staff member for the San Juan Project to arrive in Silverton. That multi-year project evaluated the effects of snowpack augmentation, through cloud seeding, on avalanche processes. Later, during the '80s, San Juan snow research and avalanche education was subsequently sustained by Chris George who continued collecting data and hosting avalanche courses at his ski-in Saint Paul Ski Lodge. Along with Bachman, George now serves on the CSAS board of directors with professors Lee Dexter, of Northern Arizona University, and Jeff Dozier, of the University of California - Santa Barbara, and with mountaineer and attorney Arthur "Boots" Ferguson, of Aspen, an expert in snow and water law.

Ahead of its time, the INSTAAR project adopted a purposefully interdisciplinary approach to understanding the influence of snow on the San Juan Mountain system, an approach that is gaining new adherents and which the CSAS seeks to foster. The CSAS Web site, www.snowstudies.org, indicates that its efforts are premised on the principle that, "When viewed holistically, as an Earth surface system driven by complex interactions over space and time between the atmosphere, lithosphere, cryosphere, and 'anthroposphere', the alpine snow system requires new insights into its behavior and crucial role in all mountain systems. Mountains, via their seasonal snowpacks and other cryospheric reservoirs, are the 'water towers of the world.' In the western United States, 50-80% of the water supply descends from the sky in the form of seasonal mountain snows. Globally, more than a billion people depend on the snow system for water supplies. Further, as settlement in mountain regions increases, the snow system increasingly poses hazards—such as snow avalanches and floods—to residents, recreationists, travelers, and human investments. Therefore, the study of how snow system processes work and change over space and time, is fundamental to understanding how the mountain realm's 'music of the spheres' influences human/environment relationships, and to developing effective policies for apportioning snowmelt resources or coping with winter hazards." Acting on those themes, the CSAS's mission is to, "…enhance the interdisciplinary investigation of the alpine snow system's behavior and role in human/environment relationships by offering resources—people, information, and facilities—for field-based research and education."

Recent drought in the West has riveted public awareness on snow as a water source that natural and human systems rely upon. "Colorado residents have become acutely aware of the role of alpine snow in our state over the past decade. The CSAS's Senator Beck Basin study area near Red Mountain Pass, which was recently authorized and developed under a Special Use Permit issued on the Uncompahgre National Forest, offers an outstanding venue for studying snow hydrology processes," said the CSAS's Executive Director, Chris Landry. He adds, "This March Dr. Tom Painter, of the National Snow and Ice Data Center in Boulder, submitted a research proposal to the National Science Foundation which would fund a three-year study of the influence of desert dusts on snowpack and snowmelt processes. As intuitive as it sounds—that dirty snow melts faster—there have been surprisingly few studies of this dramatic effect on the release of water from alpine snowpacks. This is precisely the kind of interdisciplinary, 'system-based' project we wish to foster and collaborate on—a study involving snow physics, snow hydrology, arid lands science, Western climatology, and remote sensing."

Meanwhile, according to Landry, the CSAS is already hosting its first student researcher, Fort Lewis College Senior Nick Casselli, who is studying snow creep at the CSAS's Swamp Angel Study Plot, a process contributing to avalanches. "Nick and his professor, Dr. Ray Kenney, contacted us last fall. Thanks to the unusually dry and mild weather, we were able to complete the development of the Swamp Angel Study Plot by headlamp on Halloween night, literally hours before the weather changed and ended the construction season. So, we're delighted that we could offer Nick a high-quality facility this winter. His project design is excellent and he is doing high-quality field research."

Bachman summed up the significance of the USFS/MSI funding, explaining, "We've worked extremely hard over the past year to prepare ourselves for receiving significant resources. This USFS/MSI support has arrived at precisely the right time and will help us get beyond the always-difficult 'chicken or egg' phase of developing a new organization like ours—all of ours. The CSAS has a very ambitious vision, there's no doubt about it, but these funds will enable us to pursue and achieve the critical objectives we've established for the coming year. It's really very, very exciting!"

Chris Landry is presently the executive director of the CSAS. Previous incarnations include graduate student at Montana State, harried avalanche forecaster in the Yule Creek valley of western

DOG TRAINING

continued from previous page

If the dog has difficulties with one of the phases, that phase should be repeated until the dog has mastered the task. The exercise is considered completed when dog has mastered all phases. This is the basis of the Swiss progression for introduction to avalanche rescue. The entire program is based on this 4 Phase progression.

Deviation from the 4-phase method should only be done if success is guaranteed. Ongoing training is then done on 50 x 50 meter field with the subject buried 50 cm (<2 feet) deep. The handler must know where the subject is buried to ensure success for the dog. When the dog alerts consistently and no false alerts are expected, the victim can be buried in locations unknown to the handler. To increase the difficulty, the search area can be extended to 50 x 100 meters and the victim buried 80cm (<3 feet) deep. In the beginning all these exercises should be done with no distractions. The instructors and handler should discuss wind and search strategies as well.

The time line for the dogs is as follows: A dog should have the 4-phase progression mastered by the end of their second season (1-1.5 years old). The dog can then move into 2-person Phase 4 progression and blind searches. The pack progression is also introduced at the end of the dog's second season. If on track, with no big corrections, the dog should be able to test for its certification between the ages of 3 and 5.

There is a whole lot more to training an avalanche rescue dog, but these are the basics that we use here at Stevens Pass, and the gist of the program used in Switzerland. There are a lot of small tricks and things to look for as the dog and the handlers are learning the ropes. It has been a fun process for us, we have learned a lot and believe we now have a good dog program, which will continue to improve and grow.

The future

Here in Washington we have begun to organize and eventually standardize the way the rescue patroller/dogs aid in backcountry rescue of avalanches burials. Our goal is to establish specialized teams designated to their perspective backcountry neighborhoods, specializing in avalanche rescue. The idea is to have a list of professionals who will be able to respond in time in front of the sheriff's rolodex. These professional should be able to assess and implement proper safety procedures, evaluate hazards, and lead an efficient, smart rescue. It is our hope that our highly trained dogs will benefit the public both inside and outside the ski area boundary. It is also our hope that our local law enforcement agencies will recognize the highly trained personal lurking in their local ski areas.

Mack and his handler, John Meriwether.
Photo by Aimee Forbes

John Meriwether works as the Ski Patrol Director at Stevens Pass in the winter and as a Wildlife Biologist with the Pacific Northwest Research Center in the summer time. He has been working with dogs for 20 years, but Mack is his first avalanche rescue dog. He has a BS in Earth Science and is a professional member of the AAA.

History of the Avalanche Program at Jackson Hole Ski Area

By Rod Newcomb

On January l, l964, Ernie Hirsch, acting Forest Supervisor, signed the permit for Jackson Hole Ski Area. This permit gave the Forest Service's blessing for the development and operation of a ski area on Bridger-Teton National Forest land adjacent to the southern boundary of Grand Teton National Park. It was signed on January l to allow the ski area developers—Paul McCollister, Alex Morley, and Gordon Graham—to obtain a low-cost loan for underdeveloped areas.

The idea for a ski area in Jackson Hole began in the late l950s and early l960s. The preferred location for a group of local Jackson businessmen—Bill Ashley, Hugh Soest, Dick Lang, and Paul McCollister,—was Cache Creek, directly above the town of Jackson. Problems with this area included an overabundance of moderate terrain and the fact that Jackson took its water from Cache Creek. Paul McCollister broke away from this group and began looking on the other side of the valley to the Tetons. Paul purchased the Crystal Springs ranch at the base of what became the Jackson Hole Ski Area.

The Forest Service had no illusions as to the potential for avalanche problems and the need for mitigation. During the summer of l964, Snow Ranger Walt Hines was hired full time from Mt. Baker to do an avalanche study that included mapping avalanche paths, gun placements, and control routes. The Forest Service built a house with garage and office for a Snow Ranger at the base of the new ski area. Gray Reynolds Jr. was assigned to work with Walt for the winter season of '64-65. Little did they know that the winter of '64-65 was to be an above-average winter with cold temperatures and one stormy spell which deposited six and a half feet of snow over ten days. As Gray relates his experiences, he and Walt would load the 75 mm recoilless rifle on the work tram, which ran from the valley floor to the top of the mountain. The rifle was then lowered from the work platform at the present Tram Tower 3, Walt and Gray would rappel down, fire the rifle, and hoist it back up to the work car. Then the packs with hand charges would be lowered down and Gray and Walt would run a proposed control route. That winter there was lots of avalanche activity. According to Gray, it was a "continual experience learning the mountain."

Dick Stillman from Berthoud Pass and Ed LaChapelle from the Alta Avalanche Study Center, two of the top avalanche experts in North America, were sent by the Forest Service as consultants to Teton Village that winter. What was learned from the winter of '64-65 was that avalanche mitigation was possible, but it would be both costly and a large part of the management of the ski area. What Walt and Gray did not know at the time was that they were pioneering an avalanche safety program which was to become state of the art with the ski patrol doing much of the work under the direction of the Forest Service.

For the winter of l965-'66, Len Miller from the Northwest was hired as Snow Ranger with Juris Krisjansons from Squaw Valley as his assistant. That winter, the job of the Snow Ranger entailed a minimum of avalanche forecasting and control, as only the chairs were open. The Rangers primarily built and tested gun tower locations for the on-mountain 75 mm recoilless rifles. Occasional trips were made up the upper mountain serviced by the work tram to run routes with hand charges.

Little did they know that the winter of '64-65 was to be an above-average winter with cold temperatures and one stormy spell which deposited six and a half feet of snow over ten days.

The entire mountain, chairs and tram, was opened for the winter of l966-'67. Juris became the Forest Service Ranger with Rod Newcomb as his assistant. Four gun placements were in use; two on the valley floor—a l05 recoilless rifle to shoot north of the tram and a 75 pack howitzer for the south side of the tram. On the mountain at about 9,500 feet, there were two 75 mm recoilless rifles: one at Tram Tower #3 and one above the Hoback Traverse. Krisjansons, taking advantage of electric power and phone lines to the top of the mountain, was the first to place weather instruments from the bottom to top of a 4,000 feet vertical rise ski area.

In the early days of the ski area, the ski area received support from the Forest Service in several ways. Initially the Forest Service funded one full time Snow Ranger to direct the avalanche reduction program. In l968 the Forest Service paid the salary of the assistant for two days. A few years later, the Forest Service paid the assistant full time during the avalanche season. The Forest Service also arranged for surplus artillery pieces and free ammunition from the Army. Scott Phillips, in charge of administering the ski area permit, even went to Denver to pick up ski-run signs provided at no cost to the ski area by the Forest Service.

In the spring of l971, Krisjansons and Newcomb left the ski area and Gary Poulson become the Snow Ranger. Poulson began to collect historic weather data on a homemade Heath Kit computer to track avalanche occurrences and to compare previous storms with current storm events. Three of his assistants of note over the years were John Simms, Jim Olsen, and Jim Kanzler. In l985 Jim Kanzler became the lead Forest forecaster, a position he held until l999, at which time Bob Comey accepted the position.

The Bridger Teton National Forest Avalanche Center now operates with four forecasters and several snow safety bosses. As funding increased, Bob Comey continued to expand the program and upgrade instrumentation at the ski area. With a $l00,000 grant from Wyoming State Trails Program, the Avalanche Center was able to install remote instrumentation for the Continental Divide/Togwotee Pass area and the Southwest Trails/Greys River area. Wind, temperature, and snowfall for these stations as well as JHMR data can be accessed on the web at **www.jhavalanche.org**.

Currently artillery consists of one l05 mm howitzer and three Avalaunchers, which are positioned to fire at large avalanche paths. The entire mountain is covered by hand-charge routes.

Chris McCollister completed a master degree through Montana State University gathering historical weather, snowpack, and avalanche data for Jackson Hole Ski Area, which was entered into an electronic database. From this database he uses his computer program to query and find storms with similar characteristics and snowpacks. This data together with his digital avalanche atlas gives JHMR forecasters another tool for producing an avalanche hazard forecast.

Rod Newcomb was an early Snow Ranger at the Jackson Hole Ski Area and the founder of the American Avalanche Institute. He is the Chair of the Arc'teryx ISSW 2004 in Teton Village, WY. He can be found in the summer on the Garnet Canyon switchbacks, on his way to guide the Grand Teton for his 41st year as an Exum Guide.

SNOW SCIENCE

Intermountain Winter Storm Evolution During 100-inch Storm Cycle

By Jim Steenburgh and Ethan Greene

Introductory meteorology and avalanche courses typically describe precipitating winter storms with conceptual models such as the Norwegian Cyclone Model, and atmospheric lifting mechanisms (convergent, convective, frontal, and orographic). In contrast, storm systems that produce large snow accumulations often exhibit complex evolutions in time and space and do not always conform to classic conceptual models of cyclone development. Precipitation type and intensity in mountainous regions are often governed by convective motions that are poorly resolved by numerical weather models and are not described by classic conceptual models. The purpose of this article is to describe a major storm cycle that occurred in the Wasatch Mountains of northern Utah and present a conceptual model of its progression. Some aspects of this event (i.e. lake-effect snow bands) are specific to the Great Salt Lake Basin. However, understanding the progression of this storm cycle, including the characteristics of each storm stage, may help field workers and office forecasters to better interpret storm observations and numerical weather forecasts. In addition we believe that everyone likes a story about a big snow storm!

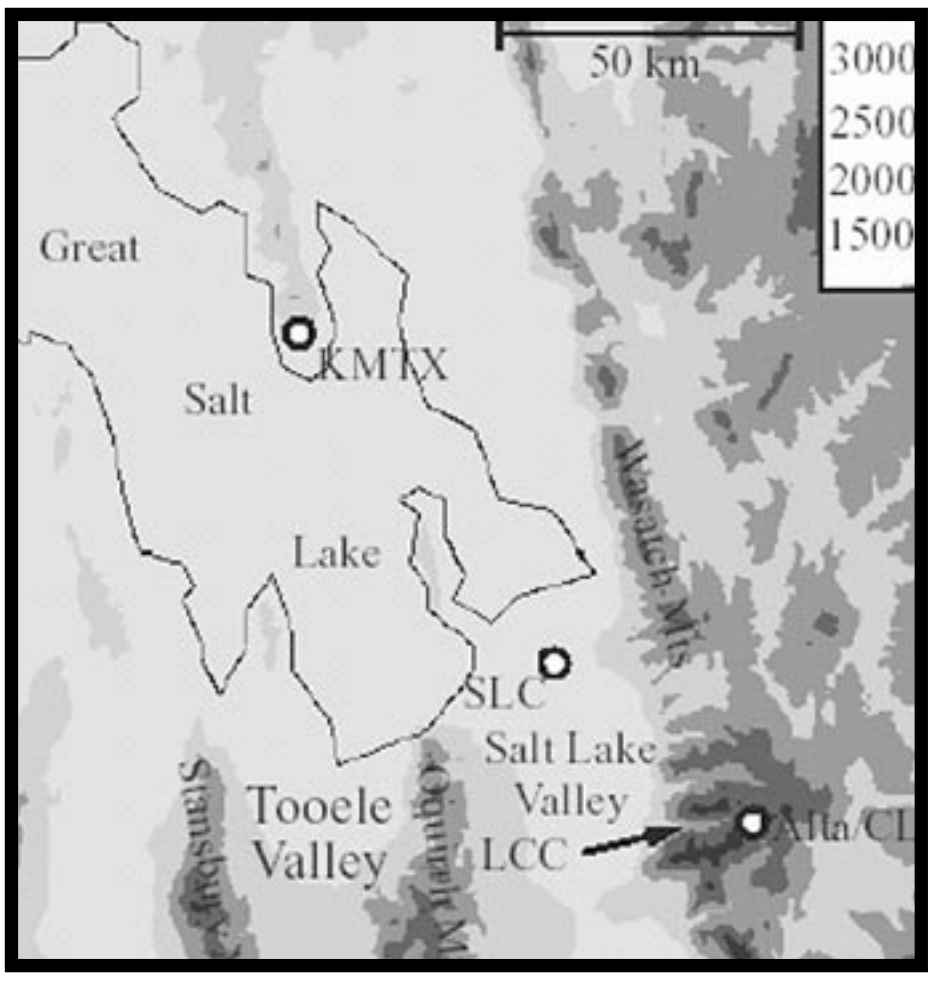


Figure 1. Topographic and geographic features of northern Utah. Abbreviations include SLC (Salt Lake City International Airport), BCC (Big Cottonwood Canyon), LCC (Little Cotton-wood Canyon), KMTX (Promontory Point radar), and CLN (Collins observing site at Alta Ski Area). Elevation and distance based on scales at upper right.

From 22–27 November 2001, two complex Intermountain storm systems produced 108 inches (274 cm) of snow at Alta ski area in the Wasatch Mountains of northern Utah **(Figure 1)**. Since 100-inches fell in 100 hours, local news media coined the phrases "100-inches in 100 hours" and "Hundred Inch Storm Cycle" to describe the event (a storm cycle is a period where multiple winter storms occur in rapid succession). The storm cycle was the largest at Alta since 1991, provided a boost for preparations for the 2002 Winter Olympics, and produced substantial lowland precipitation. Salt Lake City International Airport (SLC) recorded 1.27 inches (32 mm) of rain on 22 November, a record for a calendar day in that month, while during colder periods, up to 33 inches (84 cm) of snow fell in the surrounding metropolitan area. The event provided an excellent example of the complex evolution of Intermountain winter storms, with storm stages delineated by the passage of large-scale weather features and their accompanying changes in stability and precipitation processes. Contrasts between mountain and lowland precipitation varied from stage to stage and storm to storm, illustrating the limitations of applying climatological precipitation–altitude relationships for short-range quantitative precipitation forecasting.

θε and Potential Instability

During the 100-inch storm cycle, large-scale circulations produced mesoscale variations in temperature and moisture. These variations contributed to a destabilization of the atmosphere during some storm stages, with the release of this instability contributing to the high precipitation rates observed during the 100-inch event. Such thermodynamics play an important role in many intense precipitation events. In this section we will introduce two commonly used thermodynamic variables and describe a simple method for diagnosing potential instability.

When diagnosing the thermodynamic state of the atmosphere, forecasters often examine variables that are conserved during an adiabatic process. An adiabatic process is one that occurs in the absence of external heating such as radiation effects, conduction, latent heating, and advection or mixing. Meteorologists commonly separate adiabatic processes into two categories; those that occur in the absence of liquid water (dry-adiabatic processes) and those that occur when the air is saturated and may contain cloud droplets (moist-adiabatic processes).

A variable that is "conserved" during an adiabatic process will maintain its value unless external processes such as mountain influences and embedded circulations add or remove energy from that portion of the atmosphere. In meteorology, two commonly used thermodynamic variables are Potential Temperature (θ) and Equivalent Potential Temperature (θε). These variables are defined as:

Potential Temperature (θ): The temperature (K) an air parcel would have after it undergoes dry-adiabatic descent to sea level (1000 mb).

Equivalent Potential Temperature (θε): The temperature (K) an air parcel would have after all moisture is condensed and the latent heat is used to heat the air, then the air parcel undergoes dry-adiabatic descent to sea level (1000 mb).

Potential temperature is conserved in air parcels that undergo dry-adiabatic transformations, and equivalent potential temperature is conserved for most moist-adiabatic transformations. By examining the vertical distribution of equivalent potential temperature (θε) we can diagnose layers of the atmosphere that are potentially unstable. Recognizing such potentially unstable layers, especially if they are accompanied by a lifting mechanism and available moisture, can be a very useful forecasting tool.

An atmospheric layer is said to be potentially unstable if the equivalent potential temperature decreases with elevation within that layer ($\partial\theta\varepsilon/\partial\zeta < 0$). Potential instability (also called convective instability) means that if the layer is lifted until its lower portion becomes saturated, convective updrafts will form. The presence of potential instability does not guarantee clouds and precipitation. Rather, both potential instability and a lifting mechanism must be present to release the potential instability. For example, potentially unstable air combined with orographic lift can produce deep convective clouds and large precipitation rates.

Time-height sections are a useful method of diagnosing potential instability. These charts depict the vertical column of the atmosphere over a point as it evolves through time. Although this type of chart is available at National Weather Service forecast offices, they are less common on internet weather sites. Some sources of time-height sections are listed in the box below.

University of Utah: many sites in the western United States.
www.met.utah.edu/jimsteen/wrf/html/wrfFrames.html

USDA-Rocky Mountain Research Station-Rocky Mountain Center: point forecasts for sites in Idaho, Montana, and Colorado (other sites may be added, inquiries can be sent to emgreene@fs.fed.us). This site also includes high resolution numerical model runs over the western U.S. and central Rocky Mountains.
http://fireweather.info

Florida State University: most points corespond to population centers, but plots include many different variables.
http://moe.met.fsu.edu/modelts/

University of Washington: sites in Washington, Oregon, Idaho, and western Montana only.
www.atmos.washington.edu/mm5rt/rt/timeheights_d2.cgi?Eta

Navel Postgraduate School: sites in California only.
www.weather.nps.navy.mil/~dkmiller/MM5/

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STORM CYCLE

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Time-height sections that depict wind, relative humidity, and equivalent potential temperature can be used to determine orographic lift, available moisture, and potential instability. When all of these ingredients are present, high precipitation intensities are likely.

Winter Storms and Mountain Ranges

Some snowstorms over Intermountain ranges can be broken down into stages that relate to atmospheric stability: stable, neutral, unstable, and dissipating (e.g., Marwitz, 1980). During the stable stage, the atmosphere is somewhat resistant to vertical motion. The low-level flow is frequently blocked and upslope flow (orographic ascent) may only occur near mountain crest level. Precipitation may cover a broad region if a large-scale feature, such as a warm front, is moving through the region. Otherwise, precipitation may be confined to over the barrier and possibly over the blocked flow region (Marwitz, 1980; Cox, 2002).

Cloud formations and precipitation that occur during the stable stage tend to be heavily glaciated (i.e. consisting primarily of ice), with little supercooled cloud liquid water. Precipitation particles grow primarily through vapor deposition, riming tends to be light, and graupel formation is rare. Snow amounts tend to be higher in mountainous areas because some orographic ascent occurs near mountain crest level, and lowland accumlations may be reduced as precipitation falls into dry air resting in the valleys and evaporates. The latter is common over the Intermountain West where dry air is frequently found at low-levels in advance of approaching winter storms.

As the upstream flow destabilizes, Intermountain storms reach their neutral and unstable stages. In the neutral stage, the blocked flow has deteriorated and many orographic storms are at their deepest (Marwitz, 1980). The unstable stage is reached when the upstream flow becomes potentially unstable. Under such conditions, orographic lift near the windward slope of a mountain range can release the potential instability, resulting in atmospheric convection and heavy orographic precipitation. Precipitation may be limited to over and very near topographic barriers, unless other factors, such as the effect of the Great Salt Lake, are playing a role.

Because the vertical motion during the neutral and unstable stages is deep and frequently intense, heavy riming and graupel formation may occur. Riming is a function of several factors, but typically intensifies with increasing cloud-base temperature and updraft strength. Cloud microphysical processes within maritime clouds are also more favorable for riming. As a result, heavy riming and graupel formation are very common in ranges like the Cascades and Sierra Nevada, but less common over Intermountain ranges. Nevertheless, graupel can occur over Intermountain ranges when optimal cloud-base temperatures and updraft strength occur.

Typically, the approach and development of surface high pressure and upper-level ridging result in atmospheric stabilization and the onset of the dissipating stage. During this stage, atmospheric stabilization usually begins aloft, resulting in an increasingly shallow layer of potential instability and more widely scattered orographic snow showers. Eventually, the available instability becomes too weak to develop precipitating clouds, leaving only shallow cumulus clouds over mountain barriers.

A unique aspect of orographic storms in the Wasatch Mountains is the influence of the Great Salt Lake. Studies suggest that this body of water increases annually averaged precipitation downstream of it by 15-20%. Lake-effect snow typically occurs in unstable, post-frontal, northwesterly flow, with heat and moisture fluxes over the lake surface acting to either create, enhance, and/or release potential instability. In some cases, intense snowbands known as mid-lake bands extend along the lake axis, across the Salt Lake Valley, and over Big and Little Cottonwood Canyons (Steenburgh et al., 2000). Such bands usually develop during the overnight and early morning hours when offshore land breezes converge over the lake (e.g., Steenburgh and Onton, 2001). Orographic precipitation enhancement can occur within mid-lake bands when they intersect downstream mountain ranges (Onton and Steenburgh, 2001).

A New Conceptual Model

In some events, a more complex storm evolution than that described above can be observed. These events, such as the 100-inch storm cycle, typically feature an intrusion of low-$\theta\varepsilon$ air aloft ahead of a surface-based cold front (Steenburgh 2003). As illustrated by Figure 2, prior to the intrusion of low-$\theta\varepsilon$ air aloft, stable precipitation processes dominate and contrasts between lowland and mountain precipitation are produced by shallow upslope precipitation enhancement at mid and upper-mountain levels and sub-cloud evaporation over the lowlands. As low-$\theta\varepsilon$ air moves in aloft, destabilization results in convection (provided large-scale or orographic ascent are present to release the instability). The intensity and depth of the convection, as well as the lowland–mountain precipitation contrast, varies significantly from case to case depending on the ambient instability, moisture, and convective initiation mechanisms.

Passage of the low-level cold front results in a period where frontal dynamics dominate precipitation generation over lowland and mountain locations. Then, large-scale destabilization results in orographic snowshowers due to the release of potential instability, although precipitation rate and duration are dependent upon the convective characteristics of the post- frontal environment and size and orientation of the local topography. Precipitation during this stage is confined primarily

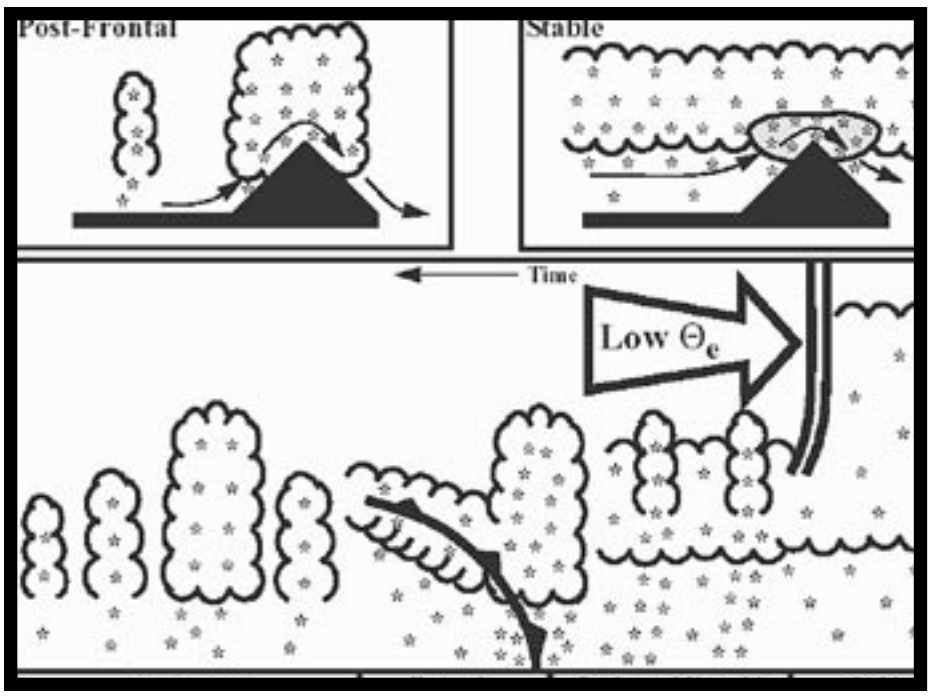

Figure 2. Conceptual model describing the evolution of Intermountain storms featuring an intrusion of low-qe air aloft ahead of a surface-based cold front. Lower portion of diagram depicts orographic effects during stable and post-frontal unstable stages.

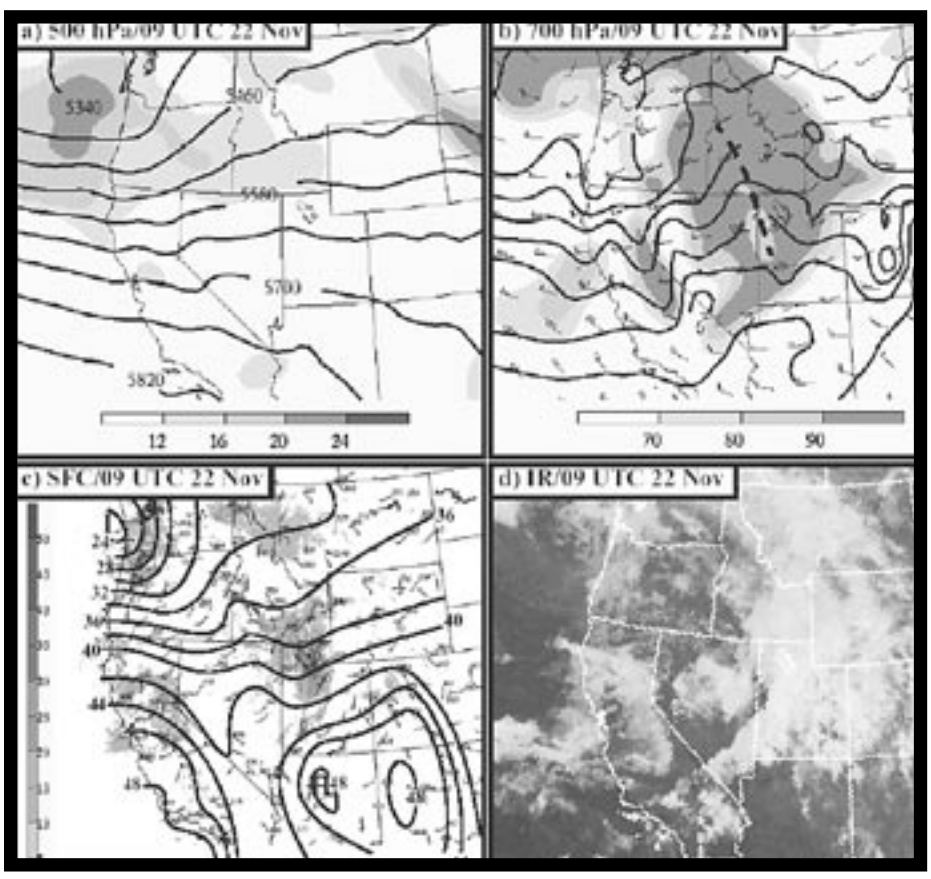

Figure 3. Manual surface, RUC2 upper-level, and satellite analyses at 0900 UTC 22 Nov 2001. (a) 500-hPa geopotential height (every 60 m) and absolute vorticity (x10-5 s-1, shaded follow-ing scale at bottom). (b) 700-hPa temperature (every 2°C), wind (full and half barbs denote 5 and 2.5 m s-1, respectively), and relative humidity (%, shaded following scale at bottom). Thermal ridge axis denoted by heavy dashed line. (c) Manual 1500-m pressure analysis (every 2 hPa) and composite radar reflectivity (dBZ, shaded following scale at left). Station observations include wind barbs [as in (b)] and 1500-m pressure (tenths of hPa with leading 8 omitted). (d) Infrared satellite image (linear enhancement curve).

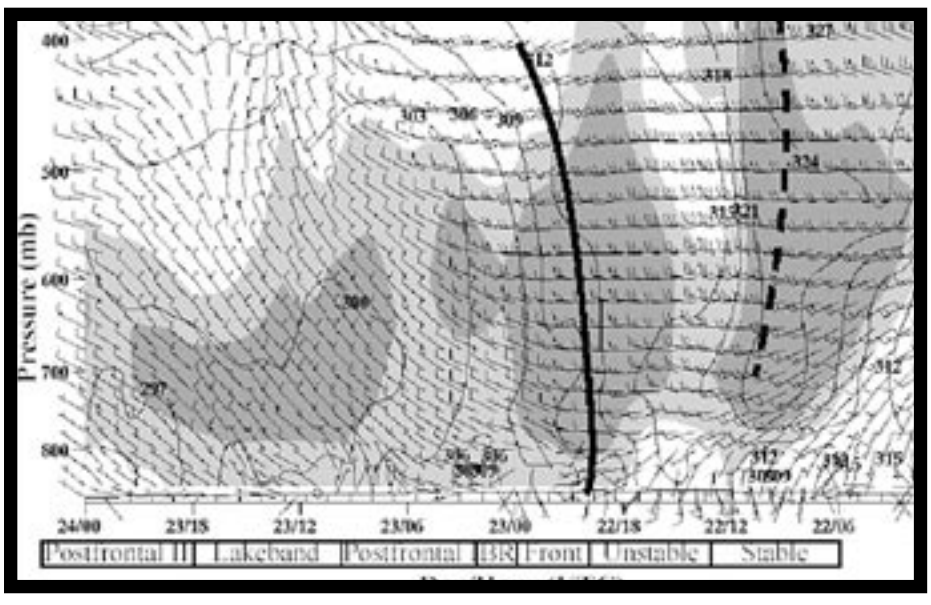

Figure 4. RUC2 time–height section analyses at SLC from the first storm (0000 UTC 22–0000 UTC 24 Nov). Plotted are qe (every 3 K), relative humidity (light and dark shading denote > 70% and > 90%, respectively), and wind (full and half barbs denote 5 and 2.5 m s-1, respectively). Heavy dashed and solid lines denote leading edge of low-$\theta\varepsilon$ aloft and surface-based cold front, respectively.

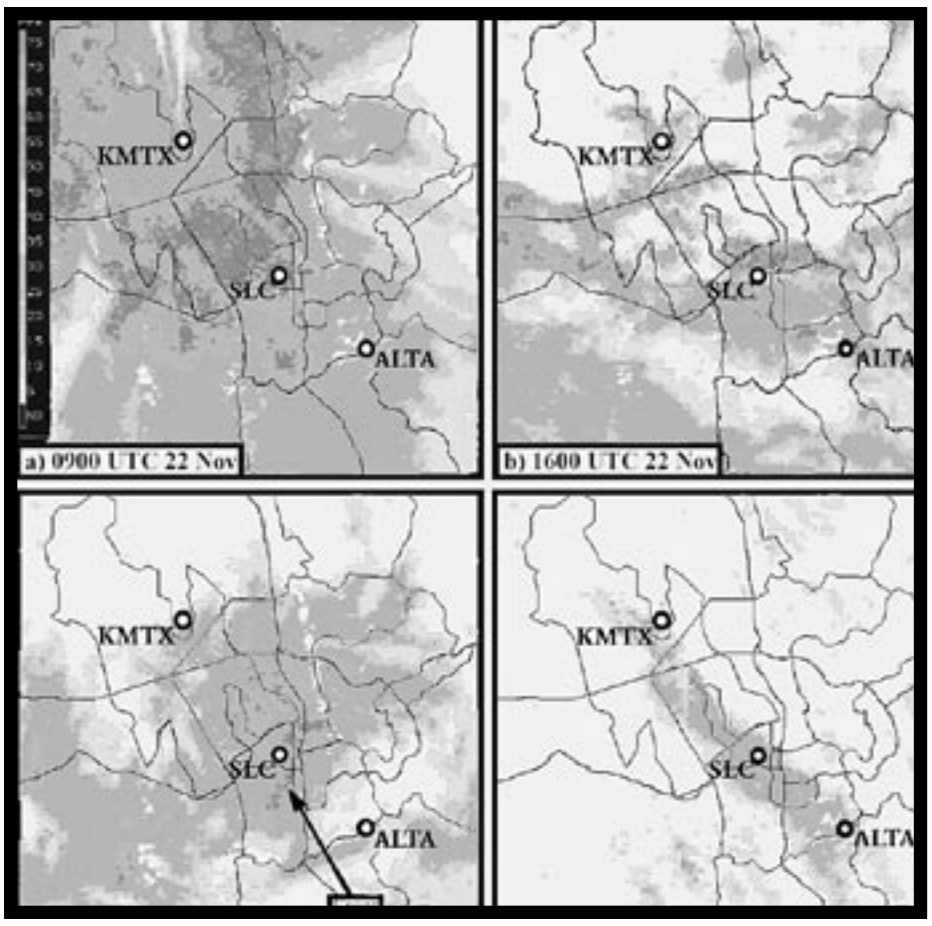

Figure 5. KMTX lowest-elevation angle (0.5°) base reflectivity analyses at (a) 0900 UTC 22 Nov, (b) 1600 UTC 22 Nov, (c) 2000 UTC 22 Nov, and (d) 1205 UTC 23 Nov. Scale at upper left of (a).

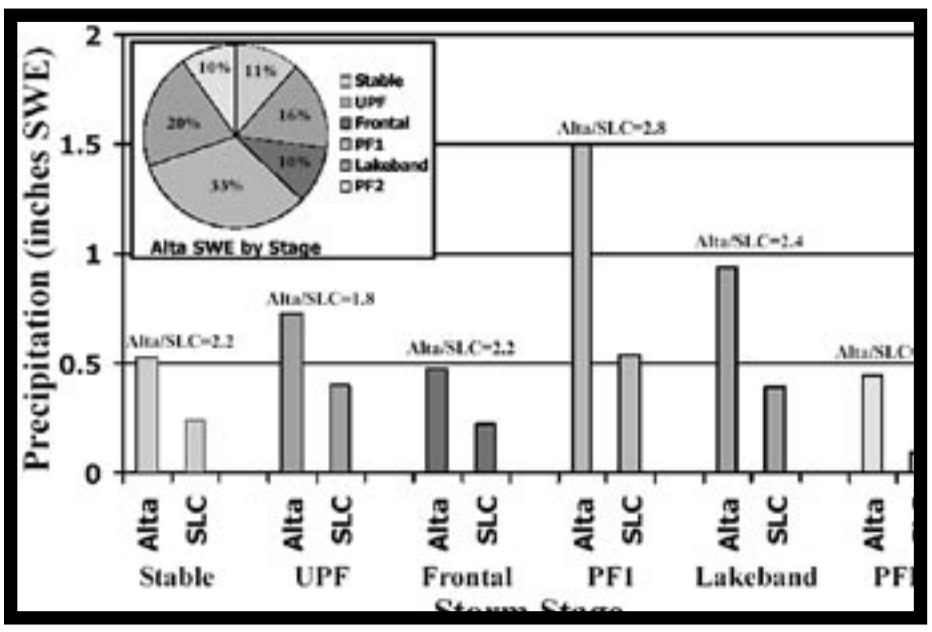

Figure 6. Precipitation (inches of SWE) observed at Alta and SLC during each stage of first storm. Pie chart at upper left illustrates the percentage of Alta SWE by storm stage. Orographic enhancement factor (Alta/SLC) annotated.

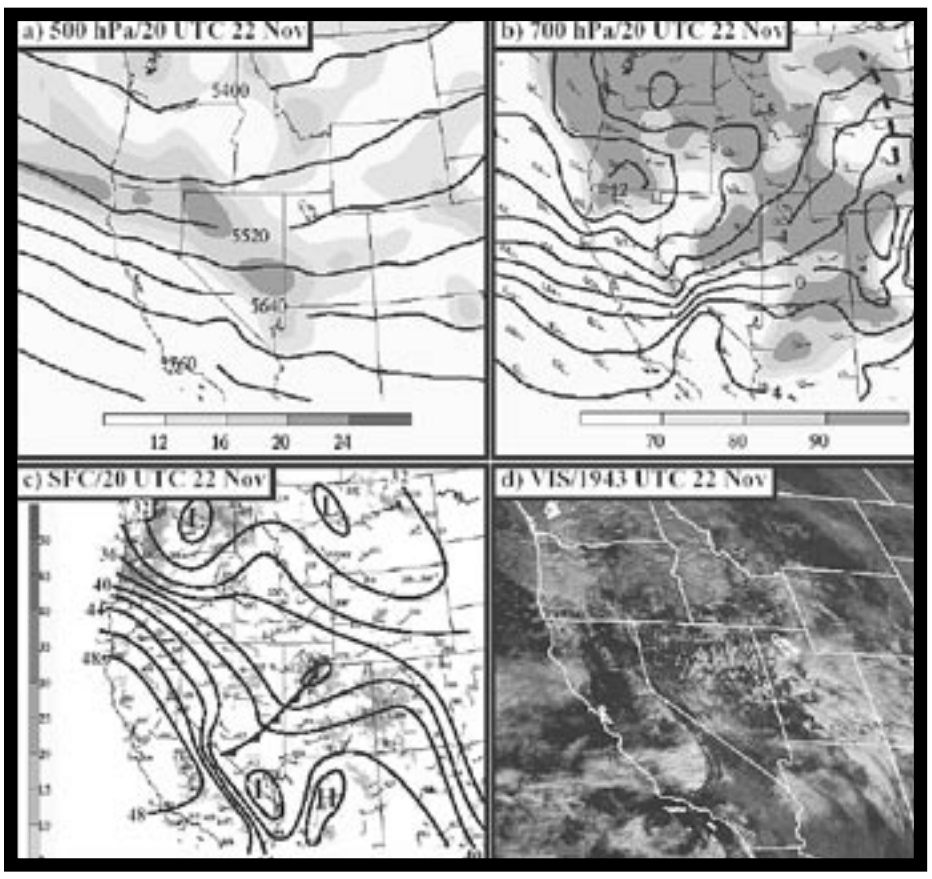

Figure 7. Same as Figure 3 except for 2000 UTC 22 Nov 2001, image in (d) is visible, and Milford, UT (MLF) identified with box around 1500-m pressure observation.

to over the mountain barrier unless other processes, such as the effect of the Great Salt Lake or terrain-induced convergence, act to generate precipitation upstream.

The 100-inch Storm Cycle

The first storm system moved through Utah from 06 UTC (Coordinated Universal Time) 22 Nov – 07 UTC 24 Nov, producing 50 inches (127 cm) of snow at Alta. At 0900 UTC 22 Nov, during the initial stable stage of the storm, a 500 mb short-wave trough and absolute vorticity maximum were located off the Pacific Northwest coast **(Figure 3a)**. Attendant with these features was a mature surface cyclone that was centered near the southwest Washington coast **(Figure 3c)**. Time-height sections for SLC, created from hourly National Centers for Environmental Prediction (NCEP) Rapid Update Cycle (RUC2) analyses, showed an intrusion of low-$\theta\varepsilon$ air aloft several hours ahead of a surface-based cold front (Figure 4). Widespread valley rain and mountain snow developed ahead of the leading-edge of low-$\theta\varepsilon$ aloft as warm advection and large-scale ascent moved over northern Utah. Precipitation during this stable stage was stratiform **(Figure 5a)** and snow-water equivalent (SWE) at Alta (2946 m, 9665 ft) was double that observed at nearby, low-elevation, SLC **(1288 m, 4225 ft, Figure 6).** One contributor to this mountain–valley precipitation contrast was sub-cloud evaporation. Lower tropospheric dewpoint depressions over the Salt Lake Valley prior to precipitation onset were 10–15°C.

Following passage of the leading edge of low-$\theta\varepsilon$ aloft, a layer of potential instability developed and deepened as $\theta\varepsilon$ decreased aloft and warm advection and solar insolation increased the low-level $\theta\varepsilon$ (Figure 4). By 16 UTC 22 Nov, scattered convective precipitation developed over northern Utah with strong reflectivity cores exceeding 35 dBZ **(e.g., Figure 5b)**. During this unstable prefrontal stage, convective initiation occurred over the lowlands and mountains. Alta received only 1.8 times as much SWE as SLC **(Figure 6)**, half the factor of 3.6 expected from climatology.

By 20 UTC 22 Nov, the surface-based cold front was moving across northern Utah **(Figure 7)** and was accompanied by a convective snowband with reflectivities exceeding 35 dBZ **(Figure 5c)**. Behind this feature, stratiform precipitation extended ~50 km (~30 miles) upstream. During this frontal stage, orographic precipitation enhancement resulted in twice as much SWE at Alta as SLC **(Figure 6)**.

After a brief break, precipitation redeveloped after 02 UTC 23 Nov as postfrontal northwesterly flow intensified, potential instability deepened **(Figure 4)**, and orographic and lake-effect snowshowers, which were heaviest and most frequent over the Wasatch Mountains and southeast of the Great Salt Lake, developed (not shown). This period, which we refer to as postfrontal stage I, produced 1.5 inches (38 mm) SWE at Alta **(Figure 6)**, 2.8 times more than SLC **(Figure 6)**.

Beginning at 10 UTC 23 Nov, precipitation was produced almost exclusively by a mid-lake snowband that extended along the major lake axis, over the Salt Lake Valley, and into the Wasatch Mountains **(Figure 5d)**. Although this was an impressive feature, it frequently shifted location so that hourly averaged precipitation rates at Alta and SLC, which were not always directly under the snowband, were smaller than observed prior to its development (not shown). Nevertheless, almost all of the SWE during this period, which amounted to 22% of the storm total at Alta **(Figure 6)**, was produced by the mid-lake band and associated orographic enhancement.

Postfrontal stage II began at 18 UTC 23 Nov when the mid-lake band weakened rapidly and potential instability release and associated precipitation became increasingly confined to the mountains. This stage featured the largest contrast between mountain and valley precipitation of the first storm, with Alta receiving 5 times as much SWE as SLC **(Figure 6)**.

In total, precipitation in the unstable, postfrontal, northwesterly flow produced 63% of the total precipitation observed at Alta during the first storm **(Figure 6)**. Just over 20% of the storm total was produced by an orographically enhanced mid-lake snowband, with lake-effect processes also contributing to accumulations during postfrontal stage I. The ratio of precipitation at Alta to that at SLC varied from 1.8 during frontal passage, to 5.0 during the last stage of the storm.

After a 12-hour break, a second storm system produced 58 inches (147 cm) of snow at Alta from 19 UTC 24 Nov – 03 UTC 27 Nov. As in the first storm, an intrusion of low-$\theta\varepsilon$ air aloft preceded the surface-based cold front by several hours **(Figure 8)**. Precipitation was initially stratiform **(Figure 9a)**, but embedded shallow convection developed following the passage of the leading edge of low-$\theta\varepsilon$ aloft **(Figure 9b)**. The contrast between mountain and lowland precipitation during the stable and unstable prefrontal stages was much larger during the second storm **(cf. Figures 6 and 10)**. In fact, only a trace of precipitation was observed at SLC during each stage, apparently due to sub-cloud evaporation during the stable stage and weaker, shallower convection during the unstable prefrontal stage. Periods where sub-cloud evaporation limits valley precipitation are so common in Utah that they are jokingly called "virga storms" by local meteorologists.

The surface-based cold front passed at ~08 UTC 25 Nov **(Figure 11)**, marking the onset of the frontal stage, which featured a convective line and a trailing region of stratiform precipitation **(Figure 9b)**. Limited orographic precipitation enhancement during this stage **(Figure 10)** suggested that frontal circulations dominated precipitation dynamics.

After 14 UTC 25 Nov, postfrontal destabilization **(Figure 8)** resulted in the development of lake and

Continued next page ➡

STORM CYCLE

continued from previous page

orographic snowshowers **(Figure 9c)**. This storm stage, denoted as postfrontal stage I, was characterized by substantial orographic precipitation enhancement, with Alta observing 3.1 times more SWE as SLC **(Figure 10)**. At ~20 UTC 25 Nov, an intense mid-lake snowband developed and dominated the precipitation pattern for the next several hours **(Figure 9d)**. The highest precipitation rates of the storm cycle (0.3 inches SWE/hr, 7.5 mm SWE/hr) were observed from 22 UTC 25 Nov – 00 UTC 26 Nov when Alta was directly beneath the snowband. Although hourly snowfall observations were not available, the snow that fell during the 12 hours encompassing this period was observed to have a water content of 6%, yielding a snowfall rate of 5 inches/hr (13 cm/hr).

At ~06 UTC 26 Nov, the mid-lake band dissipated, marking the beginning of postfrontal stage II, which featured periods of orographic and lake-effect snowshowers until 03 UTC 27 Nov. As observed during the final stage of the first storm, precipitation was confined largely to the mountains, and Alta received 14 times more SWE than SLC.

Similar to the first storm, 64% of the storm-total SWE at Alta was produced by postfrontal orographic and lake-effect snowshowers. Thirty-three percent of the storm total was produced by an orographically enhanced mid-lake snowband. For the entire storm-cycle, 63% of the Alta SWE was postfrontal, with 26% produced by orographically enhanced mid-lake snowbands. Lake-effect also enhanced precipitation during the postfrontal I stage of both storms.

The storm evolution described above is more complex than that described by Hobbs (1975) and Marwitz (1980) for the Cascade and San Juan Mountains, respectively, which feature a relatively continuous progression through stable prefrontal, transitional frontal, and unstable postfrontal stages. Complicating the evolution of each storm in the Hundred Inch Storm Cycle was an intrusion of low-$\theta\varepsilon$ air aloft, which resulted in a transition from stable to convective precipitation ahead of the surface-based cold front. Forecasters should be aware that prefrontal surges of low-$\theta\varepsilon$ air aloft may produce significant changes in precipitation processes, snowfall rates, and the magnitude of orographic enhancement. Time-height sections from numerical forecast models are particularly useful for identifying the existence of surges of low-$\theta\varepsilon$ air aloft.

Finally, orographic precipitation enhancement during the Hundred Inch Storm Cycle varied substantially from stage to stage and storm to storm, and frequently deviated from that expected from climatology. Such departures illustrate the limitations of using climatological precipitation–altitude relationships to infer the mesoscale precipitation distribution over complex terrain. Additional work is needed to better understand the factors that control the magnitude of the orographic precipitation enhancement in order to better predict the distribution of snowfall in mountainous regions.

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Jim Steenburgh is a professor in the Department of Meteorology at the University of Utah in Salt Lake City. Jim became interested in mountain meteorology during many childhood outings in the Adirondack Mountains, and became a certifiable mountain weather nut after moving west to find bigger mountains and deeper snow.

Ethan Greene is a graduate student in the Department of Geoscience at Colorado State University and serves as Chair of the AAA Research Committee. Send questions or comments regarding this article to jimsteen@met.utah.edu or greene@cnr.colostate.edu.

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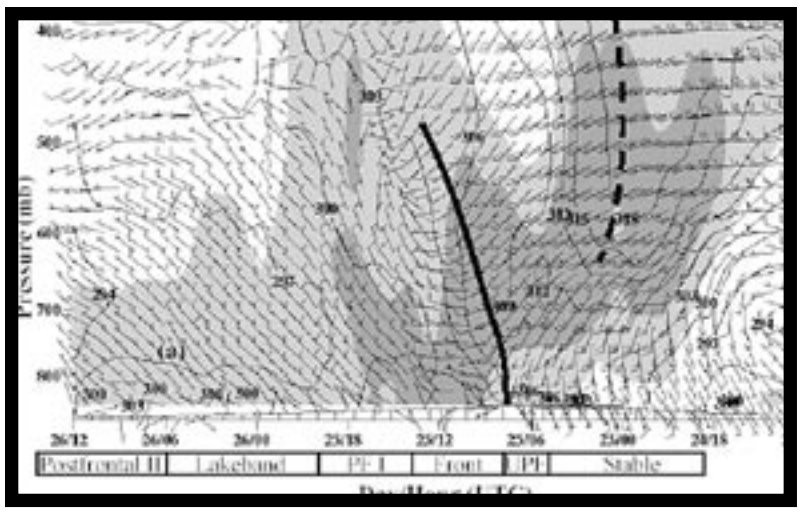


Figure 8. Same as Figure 4 except for second storm (1200 UTC 24–1200 UTC 26 Nov).

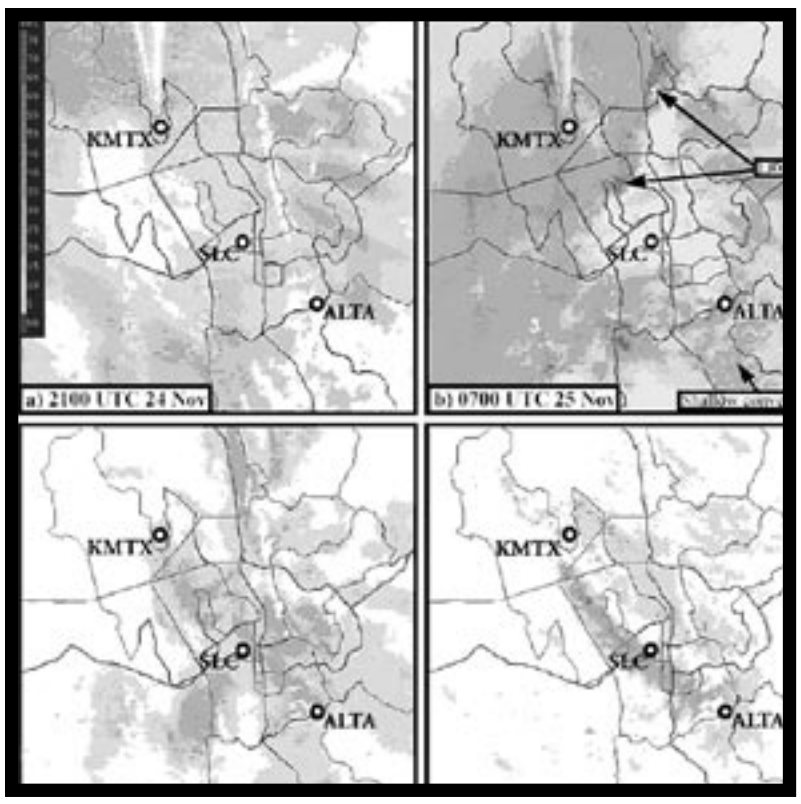


Figure 9. KMTX lowest elevation angle (0.5°) base reflectivity analyses at (a) 2100 UTC 24 Nov, (b) 0700 UTC 25 Nov, (c) 1720 UTC 25 Nov, and (d) 2340 UTC 25 Nov. Reflectivity scale at upper left of (a).

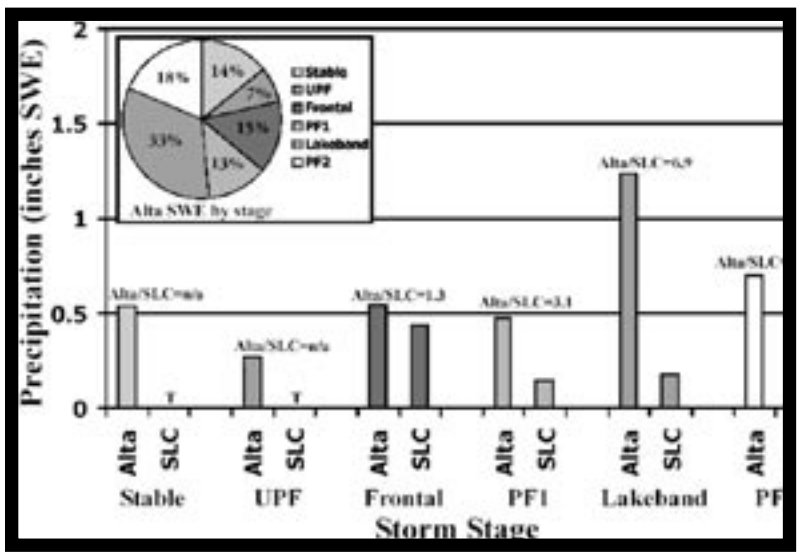


Figure 10. Same as Figure 6 except for the second storm.

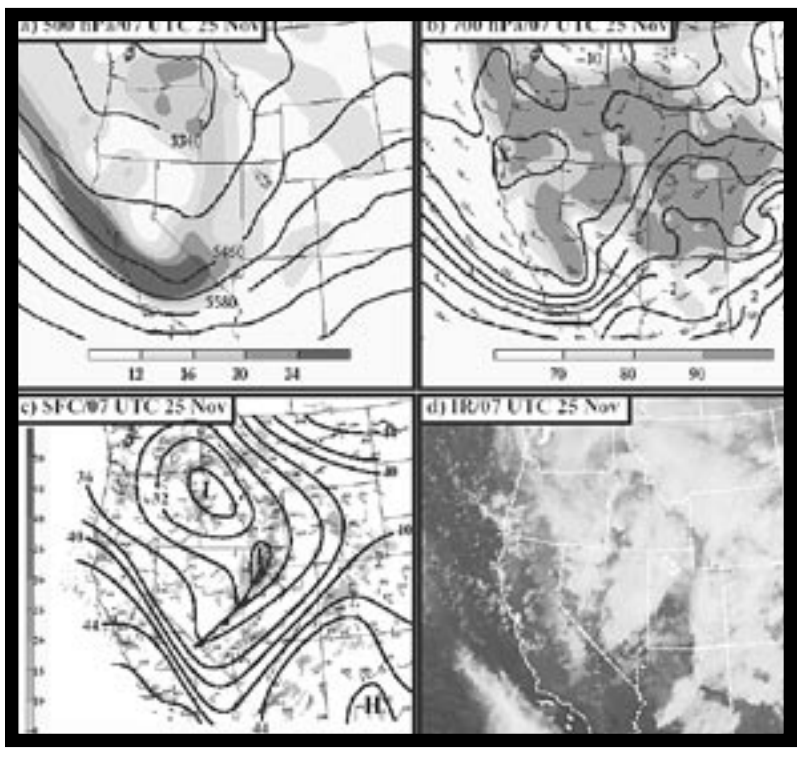


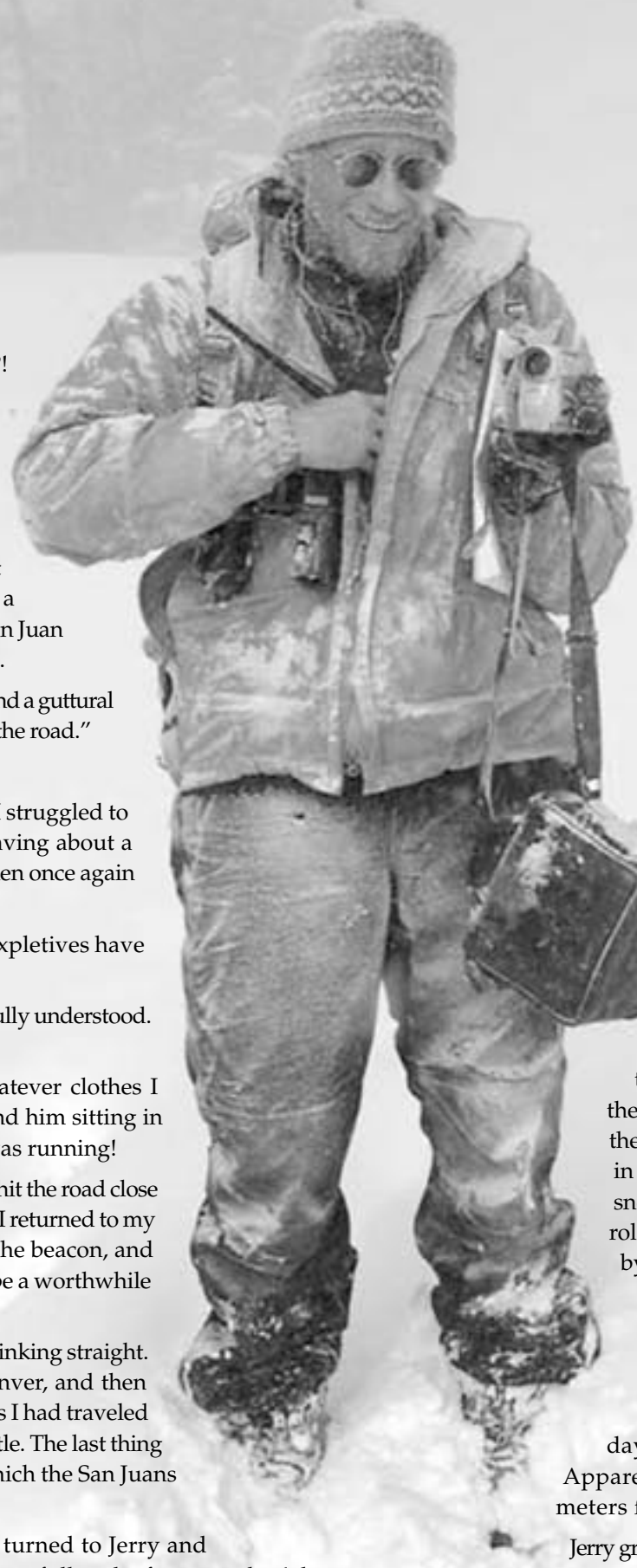
Figure 11. Same as Figure 3 except for 0700 UTC 25 Nov 2001.

Tigers on the Road

By Mark Rawsthorne

Andy had come to a halt a couple of meters away. He was plastered with fine particulate snow and was almost spectral in his appearance. He was also convulsed in fits of laughter.

"Can you believe it," he kept repeating, "Can you believe it?"



Critical Mass

"HEY, HEY! WAKE UP, WAKE UP! There's tigers on the road!"

And that is how it ALL started!

It was January the first, 2004. It was the first day of my four-month Forecasting Internship with the Colorado Avalanche Information Center (CAIC) based out of Silverton, and it was the first day of a three-day storm that would pound the San Juan mountain range in Southwest Colorado.

The light in the Dungeon sparked to life and a guttural voice bellowed from above, "…Tigers on the road."

Tigers. What about tigers?

I was semi-conscious. It was 3:00 am. I struggled to surface from a pleasant dream I was having about a particularly fine prawn vindaloo. And then once again I heard the voice.

"There's tigers on the road. MOVE (expletives have been removed)!"

And then with a shocking realization I fully understood. AVALANCHE!

I stumbled out of bed, threw on whatever clothes I could find and went to find Jerry. I found him sitting in his orange CDOT pickup. The engine was running!

"Do you have your beacon? A slide has hit the road close to the Brooklyns on Red Mountain Pass." I returned to my basement abode, picked up my avalanche beacon, and decided that a pair of gloves might also be a worthwhile addition to my attire.

I was tired! I was very tired! I wasn't thinking straight. Antarctica, Punta Arenas, Santiago, Denver, and then Silverton. In the preceding couple of days I had traveled too much and I had definitely slept too little. The last thing I needed now was a storm the like of which the San Juans hadn't seen since 1997.

I climbed back into the orange rig. I turned to Jerry and quoted an old movie (almost), "We have a full tank of gas, we don't have a half pack of cigarettes, it is dark and we're not wearing sunglasses. Hit it!" And just like Jake and Elwood we hit it. And what we hit was a seemingly impenetrable wall of snow, a swirling and churning maelstrom of white that was illuminated by the truck's lights.

We pulled away from the safety of Jerry's house, and after making a couple of turns we found ourselves inching down Silverton's main street. It was deserted. The bars and restaurants were empty and not a soul could be seen braving the elements. I for one was incredibly jealous of each and every one of them.

A couple of minutes later and we were passing the city limits sign; I slowly turned to face the way we had come and witnessed the last of Silverton's lights disappearing into the heart of the storm. Immediately I felt an eerie chill trace its way down my spine. I was scared. I felt naked! Naked with regards to knowledge. A myriad of questions danced in my mind. Snow-pack history, storm history, aspect, terrain, wind loading, temperature gradients? I had only just arrived in Silverton, I had no idea how the initial storms had bonded to one another, how they had settled, and how the distinct layers had metamorphosed. Critical information that every forecaster requires was missing! Yes I was scared, and yes I was heading out into the middle of the storm!

As we moved further up the pass the increasing intensity of the storm began to devour the truck's lights. The imposing darkness added to my fear. Knowing that avalanches had begun to run didn't help. It took us thirty minutes to travel ten miles, almost all of which was in silence. The driving conditions were appalling. The concentration etched on Jerry's face was of an intensity I hadn't witnessed before. His eyes darted every which way. He searched for clues in the depths of darkness, clues that might give him information as to the movement of the white beasts.

The truck rounded a long curve in the road. Jerry turned to me and informed me that we had arrived at the Brooklyns. Initially there wasn't much to see except the continued waltz of the innumerable flakes. And then in the distance a flashing light became visible, a CDOT snow plough. We pulled alongside the six wheeler, Jerry rolled down his window, and we were instantly greeted by a mischievous grin.

"What's happening Corky?" Jerry asked.

"Well Jer, looks like we got ourselves a proper San Juan howler."

That I thought was the understatement of the day. Corky and Jerry chatted for a couple of minutes. Apparently, the slide had come down about a hundred meters further down the road.

Jerry grinned as he said "Well let's go and take a look. Shall we?"

He turned to Corky, said his farewells, and put the truck into first.

The slide, if that's what it could be called, was a bank slip. It had dribbled its way about a meter from the edge of the road and it was roughly five meters long!

Jerry turned to me and said. "The plough drivers can sometimes get extremely excited."

Apparently we hadn't quite reached critical mass.

"Well let's go back and get a few more hours sleep," Jerry said.

In fact, we managed to get just over an hour's additional sleep.

HAPPY NEW YEAR!

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TIGERS ON THE ROAD

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The Beginning

Everybody has a list of their own favorite locations across the globe. The terrain that borders highway 550 between Ouray and Durango in southwest Colorado is one of mine. The San Juans are breathtaking. Their magnitude and splendor rival that of most mountain ranges, and for four of the past five years their beauty had drawn me back. This year, however, things were different. This time I wasn't just here to play. This time it was official; I was here to study. My good friend Jerry Roberts (one of the two CAIC avalanche forecasters for Highway 550, the other being Andy Gleason) had suggested the idea, while he was visiting my neck of the woods in central Chile.

"Have you ever thought about interning with us in Silverton? It would be good for you to experience forecasting in a continental snowpack."

The seed had been planted, and for the next month and a half I thought, I thought some more, I deliberated, I panicked, and I did a large amount of financial soul searching. Finally through the combined pull of the San Juans and the chance of learning from two of the best forecasters in the States, I decided to give it a go.

Taming the Beast?

"Internationally, explosives are not known to promote stability in structures."

—Art Mears

The new day started as the previous day had finished. Namely with bloodshot eyes and Jerry bellowing into the dungeon, "Wake up, we're going to do control work!"

Well at least there was no mention of any zoological entities. I didn't need to dress, as I had passed out an hour earlier fully clothed. I headed upstairs looking forward to a hearty breakfast. I was woefully mistaken.

"You better get some sandwiches made; we have to leave in about ten minutes!"

Morning, Jerry.

When I first decided to take the internship, there was a definite strategy of mis-information. Nowhere was it stated that the intern was required to be chief sandwich maker for the entire season. Later on I was also to find out that being an intern also involved being chief receptionist, chief data enterer, chief breakfast maker and chief in command of trail breaking.

We left the house in a storm. A storm met THE storm. It was still snowing an inch an hour in town.

"So what's the plan?" I asked Jerry.

"Well there's going to be three crews performing control work. You and I will take the south side, Andy is going to start shooting on the north side, and the other Mark will be shooting over at Lizard Head."

I nodded, fastened my seat belt and prepared myself to once again enter the eye of the storm.

As we drove to meet the gun crew I asked Jerry what he thought it would take to start to bring things down.

His reply, "Ahhh, probably the last snowflake."

From an aspiring forecaster's standpoint, his answer was quite a surprise and one which left me feeling incredibly perplexed. It wasn't the response I was looking for. I wanted a number. A water equivalent value. I was used to dealing with hard scientific facts and not the last snowflake-style response.

But as I sat in the truck and watched the piled banks of snow pass in a blur, I realized it was the only true answer he could give me. We were both acutely aware that the snowpack couldn't take much more of a load. Precipitation intensity was elevated, there was significant wind loading, and it had been snowing constantly for 24 hours. If Jerry had said the snowpack would take an additional inch of water or even an additional half an inch, then I would have been able to sit back and relax in the false comfort of scientific reasoning. But the "last snowflake!"

I realized then what Jerry was trying to say. Forecasting can never be an exact science. There were just too many unknowns, too many hidden variables for even the human brain to compute. Right after this thought had left me reeling, a second notion leapt forward and delivered a knockout blow. If you can never predict with one-hundred percent certainty when avalanches are going to run, then there will always exist the slim possibility for disaster. This was not something to be taken lightly, and as I studied Jerry as he drove the orange pickup I became acutely aware of the burden that hung on his shoulders. The enormity of his and Andy's task along Highway 550 was immense.

Luckily for them, CDOT was at hand. The boys from the Colorado Department of Transport (CDOT) performed all the mitigation work for Highway 550. I'd gotten to know a number of the crews over the past five years, and funny enough I liked them. Today our particular method for taming the beast was the Avalauncher. CDOT also had at its disposal a couple of 105 howitzers, and a helicopter and its Vietnam-vet pilot, Bob.

When we finally arrived at our initial firing position the launcher was almost ready to be fired. It was 7:30. The explosives were being built, the gun assembled and positioned; all we were waiting for was a final sweep of the road and then the entertainment could commence.

Unfortunately for everyone, the entertainment was seriously disrupted by poor visibility and high winds. Small sucker holes of visibility appeared and disappeared during the course of the day, teasing us with their brevity and irregularity. Frustration was the name of the game. By the time we began to lose the light of day, we still had a large portion of the corridor to mitigate. Jerry was nervous. The road was still open and the snow showed no sign of abating.

He said, "We need to shut this road down."

The ultimate decision to shut the road could only be made by CDOT. All Jerry could do was advise and make recommendations. Recommendations were made to close the road and, for whatever reason, the road remained open. Jerry turned to me and said, "Oh well, let's go back to the house and get something to eat. It's probably going to be a very long night." The mark of frustration was etched across his face.

Morning, Jerry.

Sleep deprivation alters one's perception of events and of time. Sometime during the night, CDOT closed the road. I can say this with a certain amount of conviction, because I was there (I think). I distinctly remember a conversation between Jerry and one of the CDOT supervisors; I seem to recall us sweeping the road; I remember closing a gate and locking a padlock. And then I remember crawling back into bed. When I awoke the next morning I initially thought I had been dreaming. However, the local radio station confirmed my sanity. Red Mountain Pass was definitely closed.

At some point during that same day, the storm decided it had had enough of the San Juans and promptly spun off to disrupt the poor folk to the east of us. Blue skies devoured the cloud and within a remarkably small amount of time it was if the storm had never even existed.

"Mate you better get ready; we've got more control work to do."

I headed to the kitchen to find a can of Spam and make sandwiches. It was Jerry's favorite. I was learning fast.

The 105 howitzer was heavy—it took a small army to move and position, it was loud, it generally shook you to bits, but most importantly, it delivered an eight-pound explosive charge to areas that needed avalanche control.

Mitigation work began on a group of avalanche paths that sat to the south of Silverton—the Jenny Parkers and the Champion. The gun placement was set beside the old railway station in Silverton and anyone who wanted could come and enjoy the show. The first couple of shots set the tone for the rest of the day. The snow wanted to move and with the aid of a few pounds of high explosives, that is exactly what it did.

It took a little under an hour for everyone to feel satisfied with the results.

"Mark, we're going to move the gun and shoot the Battleship. Do you want to come with me to the forward spotting position?" Andy asked. Now there was a proposition that no discerning snow geek could refuse. The Battleship was a slide path about five miles north of Silverton. It had numerous catchment basins and the entire path ran for over three-thousand vertical feet into a deep gorge. The path held a special allure for me. My next door neighbor and mentor down in Chile, Tim Lane, had taken a famous sequence of photographs of it running full-track twenty years ago. It was those shots that had initiated my interest in snow seven years ago.

The view from the forward spotting position was impressive to say the least. The entire path was visible in its finest glory. Not a cloud specked the sky and the blue of the heavens was of a clarity reserved for moments after a storm when the air is cleansed of all its impurities. A radio crackled. The gun crew was ready to commence.

"What do you think is going to happen," I asked Andy.

"I don't really know," he replied.

And then in the distance we heard the distinct but muffled sound of the howitzer firing.

We both raised our cameras and waited.

Hole.

Disappointment. Andy radioed the CDOT boys, gave them the results and told them to move right.

Second shot.

Hole.

Andy once again got on the radio.

"Hey why don't you try the far right shot, it looks like the snowpack's slightly thinner there." Spatial Variability!

Once again the howitzer sounded and once again both Andy and I raised our cameras. What happened next will stay with me until the day I die.

The shot placement was perfect. A small plume of grey smoke rose skyward from the shell's detonation point.

Initially I thought there was just going to be another dirty grey hole marking the impact point, but then through my camera's viewfinder I began to see movement. Cracks darted in a multitude of directions.

"It's moving," I heard Andy yell.

The initial seconds after the shot saw the slab lose its internal strength, become an amorphous mass, and increase in velocity. It was running big. Real big!

"It's definitely moving," I heard myself yell.

The slide continued to gain momentum and before too long the full extent of what we had unleashed was evident. A nebulous giant. A foaming white monster intent on destruction.

At the exact time that part of my brain was marveling at the slide's beauty, splendor and magnitude, another more primal part started to think of self preservation.

I turned to Andy. "Do you think we should move?"

The reply was non-verbal. There was a blur of motion and there Andy was, five meters ahead of me running with the sole intent of escaping the air blast. I think that if someone could have recorded Andy's time for the one-hundred-yard dash, it might have been excruciatingly close to a new world record. And that was with him simultaneously carrying a camera, a rucksack, a clipboard and a pair of ski poles. Impressive!

…I thought there was just going to be another dirty grey hole marking the impact point, but then through my camera's view-finder I began to see movement. Cracks darted in a multitude of directions.

It took me a fraction of a second to come to the same conclusion.

Run away, run away, run away.

The thought of running from an advancing powder cloud whilst simultaneously trying to take holiday snapshots seems ludicrous now. But that is what I did. It was obvious the blast was going to overtake us; what we tried to do was distance ourselves from the zone of highest impact. It definitely worked as both Andy and I were to later find out.

The force exerted when the powder cloud finally reached us was impressive. I had prepared myself as best I could; I was close to the ground, I had my head between my legs, and my camera was stashed in my jacket. The initial wave must have registered between 40 and 60 km/hr. It soon dropped to 20-30km/hr, but this continued for about 3 minutes! The sensation was exhilarating to the extreme. My heart pounded, adrenalin pumped, and I found myself laughing hysterically. When finally the blast's velocity dropped to a manageable level I stood up and began to brush myself off. It wasn't too long before I made a mental note to myself: when dealing with powder clouds one should always make sure that all one's pockets are closed, especially those with expensive electronic devices in them.

Andy had come to halt a couple of meters away. He was plastered with fine particulate snow and was almost spectral in his appearance. He was also convulsing in fits of laughter. "Can you believe it," he kept repeating,"Can you believe it?"

The hilarity of the situation was interrupted by the sound of the radio, "Did you get any results?" It was the gun crew. We both doubled over and laughed uncontrollably for a minute or so before we responded. "I think we can move on and shoot Cement Fill (the next slide path on our control route) now," Andy said. The Battleship had run full track, wall to wall, 3000 vertical feet. There was a five- to eight-foot crown line and, as Andy and I discovered, the air blast had knocked two live fifty-foot trees across the highway.

Ten minutes later and the gun crew arrived on the scene. I went to find Jerry. I'm sure I looked comical with my big cheesy grin and snow-covered clothes. I didn't care. I held out my camera, pointed to it, and exclaimed, "I think I just got the money shot!"

The day was by no means over. We still had to shoot a host of additional slide paths. However, my head and heart weren't into it. How could it get better than the Battleship? I floated from firing site to firing site, until finally close to five in the afternoon the road was officially reopened. Jerry turned to me and said, "Well mate, let's go home and get a nice cuppa Tetleys."

As Andy and I discovered, the air blast had knocked two live fifty-foot trees across the highway.

"That sounds like a great idea, Jerry."

And that was the end of the beginning!

Mark Rawsthorne (known as "The Brit") is an itinerant adventurer who spreads his time between the San Juan Mountains of southwest Colorado and the Chilean Andes. He is a snow-viewer extraordinaire, working with the CAIC/CDOT crew in Silverton, CO, and Ski Portillo in Chile. He is also the Master and friend of "Reggie" the avalanche dog.

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