2013-2014 Winter Season Snowpack and Avalanche Summary: Evolution of the Deep Slab Problem

Crested Butte Avalanche Center

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Although snowfall amounts this winter came in only slightly above average, it was an exciting and memorable winter from an avalanche perspective. Highlights include exceptional coverage during the fall months, a historic storm and avalanche cycle in February, perplexing deep slab problems, and several significant dust events during the spring.

Snowfall arrived and stayed early in the peaks around Crested Butte, with several significant storms in October and November. By the time our forecast center was in operation on November 27th, Schofield Pass had received 9.2" of snow water equivalent (SWE) and had a 42" base. An early November dry-spell capped by a significant snow and wind event on November 15th established the brick-over-potato-chips foundations for the rest of our season to build upon. This plaguing facet layer was already rearing its ugly face on Day 1 (Figure 1), and our forecast team was blessed with opportunity of describing persistent weak layers in almost every single advisory of the season. By the time most locals had exchanged their skis for mountain bikes or kayaks in June, we were still observing full depth wet slab avalanches, most likely on this same layer.

Figure 1: A pair of skier triggered and sympathetic avalanches in Redwell Basin. One skier was carried and partially buried. November 29, 2013. Photo credit: Ben Pritchett

Our first avalanche warning came on December 4th, when a quick hit up to 2.4" of SWE provided ample evidence that the basal facet layers were alive and well, as well as more recently buried surface hoar and near surface facet layer that formed during the prior week's dryspell.

Figure 2: Remotely triggered avalanches from Scarp Ridge. Note the skiers for scale. December 5, 2013. Photo credit: Zach Guy

With continued unsettled weather into January, favored zones saw an additional 2-3” of SWE into the New Year. The unseasonably warm interims between relatively small storm cycles in December aided in several crusts, facets, and surface hoar layers to form. These shallower weaknesses came to the forefront of our concerns, with a diminishing number of reminders that the monsters in the basement were still lurking (Figure 3).

Figure 3: Skier triggered soft slab on Mt. Owen that stepped down into older weak layers near the ground. January 2, 2014. Photo credit: Alex Fenlon.

A sustained snowy period returned in early January favoring the Irwin area with 65” and 4.0” of SWE over an 8 day period. The storm culminated with two days of high danger after 33” of snow (2.1” SWE) fell under extreme wind speeds. The resulting avalanche cycle included an abundance of natural wind slabs and a few very large slabs that ran on December crust layers or older facets (Figure 4).

Figure 4: Large hardslab near Yule Pass that likely failed naturally during early January storms on old crusts and/or facets.

Almost two weeks of "Juneuary" followed: mild and sunny days that quickly transformed the snow surface to facets on wind sheltered shaded slopes and added a stout crust layer on southerly exposures. The absence of any loading over 12 days put deeper persistent weak layers in an unreactive state and we enjoyed almost a week of low danger – the calm before the storm.

A storm of historical significance came barreling into the Elk Mountains beginning on January 30th. It started with a short spell of freezing rain followed by a massive hit of roughly 4.0" of SWE in the favored zones and 2.0" of SWE near town in just 60 hours accompanied by extreme gusts. We had a brief clearing on February 2nd which gave us a good view of widespread natural avalanches. These were all confined to the new snow, and most common at lower and shaded slopes where the surface snow was weakest. For such a quick load, we were a little surprised that nothing larger ran.

Modest accumulations (1" to 1.5" of SWE) under lighter wind speeds continued from February 3rd through February 7th with a lull in reported avalanche activity. On the night of February 7th, the Pacific river of moisture found a bullseye over Crested Butte, burying the mountains with another 3.5" of SWE in the favored zones over the next 3 days as winds increased. As the storm cleared on February 10th, one third of the entire season's snowfall to date had fallen in just 12 days. Schofield Pass reached 9.5" of SWE, which is one of the largest storms that site has seen since it was installed 30 years ago (Figure 5). Irwin reported 96" and 8.3" of SWE. The avalanche danger was rated high on five of those days, with avalanche warnings on four of them.

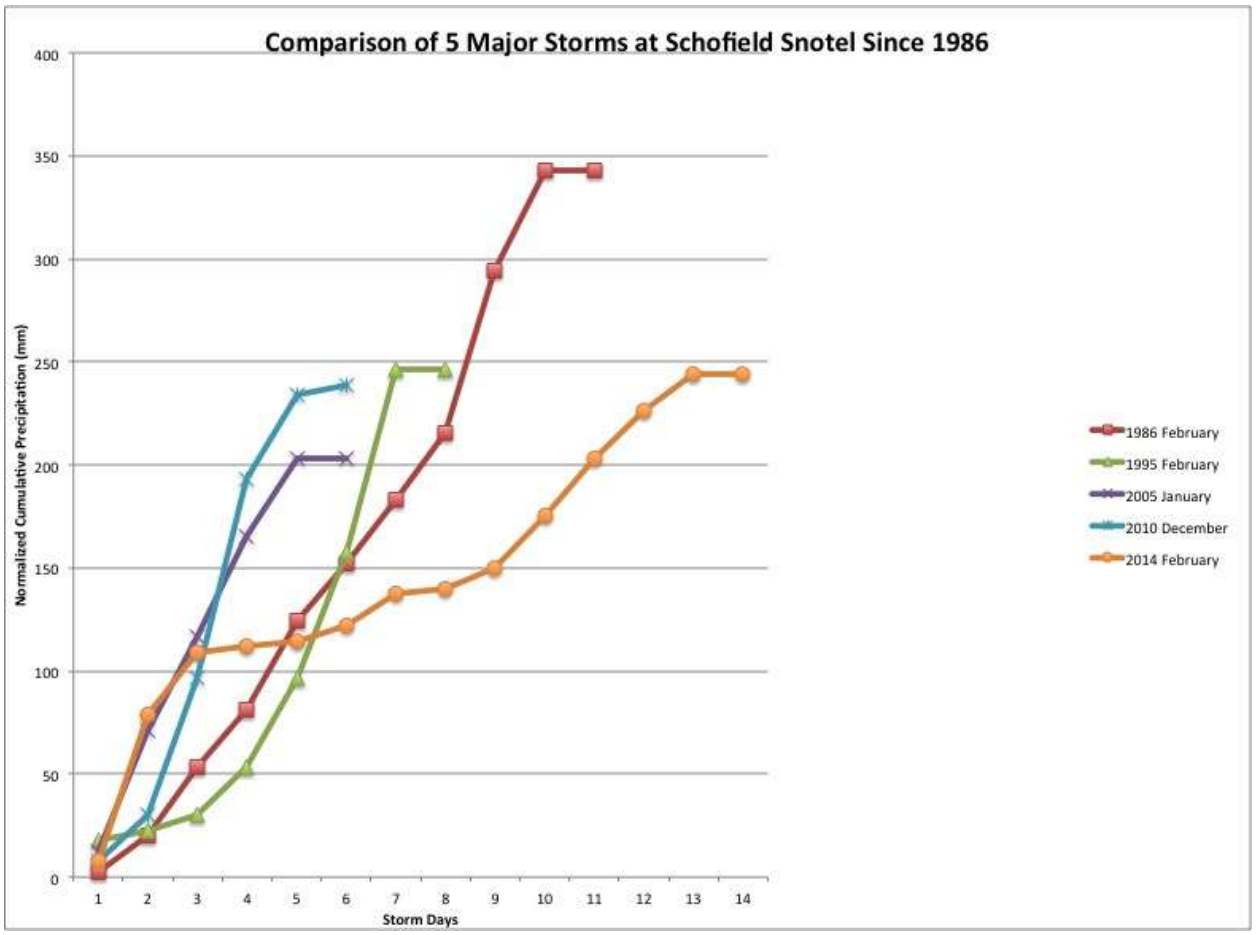

Figure 5: Comparison of 5 major storms at Schofield Snotel site since 1986.

The tail end of the storm produced utter carnage. Dozens of full-depth, full-track avalanches littered the landscape. Local roads, such as Peanut Lake Road, Cement Creek Road, Gothic Road, and Taylor Canyon Road were covered in debris (Figure 6). We received reports of slides widening historic runouts, and of structures being impacted and destroyed. Several slides were estimated as D4's, and many unusual crowns were observed. One was over a mile wide (Figure 7) and several were up to 10 or 20 feet deep (Figure 8). Additional photos and descriptions of this cycle can be viewed here:
http://www.cbavalanchecenter.blogspot.com/2014/02/recapping-historic-avalanche-cycle.html

Figure 6: Large slab avalanche that failed near the ground and crossed Peanut Lake Road on February 10, 2014. Photo credit: Ben Pritchett

Figure 7: A very destructive avalanche in Middle Anthracite Creek that occurred during the February cycle. One of the crowns was approximately 6,000 feet wide with debris deposits filling over a mile of valley bottom. Photo credit: Zach Guy

Figure 8: Deep slab on Mt. Afley that failed during the early February cycle. Photo credit: Ian Havlick

Negligible amounts of snow fell under increasing wind speeds over the next week. Temperatures started to climb, almost reaching 50ºF in Crested Butte. We even saw short bouts of rain at all elevations. The spooky deep slab cycle continued, with observations of fresh full-depth avalanches rolling in almost every day into mid-February (Figures 9 and 10).

Figure 9: Exploring the debris of a deep slab avalanche near White Mountain that ran in mid February. Part of the crown is faintly visible in the distance. Photo credit: Chris Miller

Figure 10: Alpenglow on the crown of deep slab off of Whetstone Mountain which likely failed February 15, 2014. Photo credit: Pete Sowar.

With less than 1.5" of SWE falling in the last two weeks of February, the snowpack was given a much-needed vacation from stress, but it was still quite slow to decompress. Even two weeks out from the end of the major storm, cornice falls (or perhaps continued windloading)

triggered a few deep slabs naturally. The pattern of deep slabs since mid February had shifted to strictly alpine start zones, but were becoming sporadic and less predictable.

March came in like a lion. Roughly 3" of SWE fell in the first two days of the month, bringing storm instabilities high on the concern list and initiating a couple more natural deep slabs. The bulk of March was rather lamblike though,, with light and intermittent snowfalls arriving with tame winds through most of the month. In our forecasts, we described the unlikely and sporadic vs. high consequence nature of these beasts on a daily basis and emphasized the threat of looming cornices as the most likely deep slab triggers. Cornices had grown to impressive sizes and were starting to sag and weaken (Figure 11).

Figure 11: A cornice fall triggered by a snowmobile along Scarp Ridge. March 24, 2014. Photo credit: Unknown

Spring-like weather arrived uneventfully on March 9th and 10th, with temperatures just cresting above freezing under sunny skies. Several days later, following a few inches of snow and colder temperatures, at least three unnerving and puzzling deep slabs released (Figures 12 and 13). All

three of these dry, hard slabs were on southerly facing slopes, and they spurred some healthy discussions between our forecast team on the mechanisms of failure, as they all appeared to fail during relatively cool, benign weather.

Figure 12: Investigating the crown of a natural deep slab on Mt. Owen that ran around March 11 on a January crust/facet layer that was buried up to 12 feet deep. Photo credit: Zach Guy

Figure 13: Deep slab near Mt. Avery that failed the night of March 11/12, 2014. Photo credit: Zach Guy

The last significant storm of our forecast season came in late March, delivering up to 3" of SWE under the strongest winds of the season (gusts up to 110 mph). Unfortunately, both ends of the storms were accompanied by major dust storms from the desert southwest, coating the snowpack with several red layers that quickly emerged at the surface in April (Figure 14). The late March snowfall delivered several flavors of shallow instabilities with dust layers complicating the problems, but for the first time since November, we did not observe any failures below the storm interface following a significant load. Finally, we had enough

confidence to pull deep slabs off of the problem list until their return as wet slabs.

Figure 14: Dusty rollerball or delicious Cinnabon? April 9, 2014. Photo credit: Zach Guy

Spring thaw began in earnest in April, with the first real meltwater and loss of SWE from our mountain snotels. Mountain temperatures climbed into the 40's, and several full-depth wet slabs failed on low elevation, southerly slopes. As our forecast center closed for the season in mid-April, we warned of the full-depth wet slab pattern moving to higher elevations and more northerly slopes. During the last week of May, temperatures spiked, with mountain highs (around 11,000 feet) reaching into the 60's and overnight lows staying in the upper 30's or low 40's. Stream hydrographs in the area showed a dramatic increase between 35% and 65% and peaked the first week of June. During this time, we observed several large, full-depth wet slabs failing on high elevation northerly aspects (Figure 16). Over six months since these layers were buried, they were still producing slab avalanches!

Figure 15: Wet slab avalanches off of Gibson Ridge that failed during the first prolonged spring thaw in early April. Photo credit: Zach Guy

Figure 16: Two wet slabs on northerly facing slopes of Scarp Ridge. Estimated failures on June 1, 2014. Photo credit: Ian Havlick

This water year, the Gunnison River Basin peaked on April 8th at 107% of the normal peak. Irwin's cat ski operation reported 502" of snowfall (34.0" SWE) and Crested Butte Mountain Resort reported 300" of snowfall during their operating seasons. As of June 1, Schofield Pass Snotel received 50.9" of SWE, and Butte Snotel received 20.3" of SWE. From October through March, the town of Crested Butte reported 182" of snow, which is 97% of its average over the past 51 years.

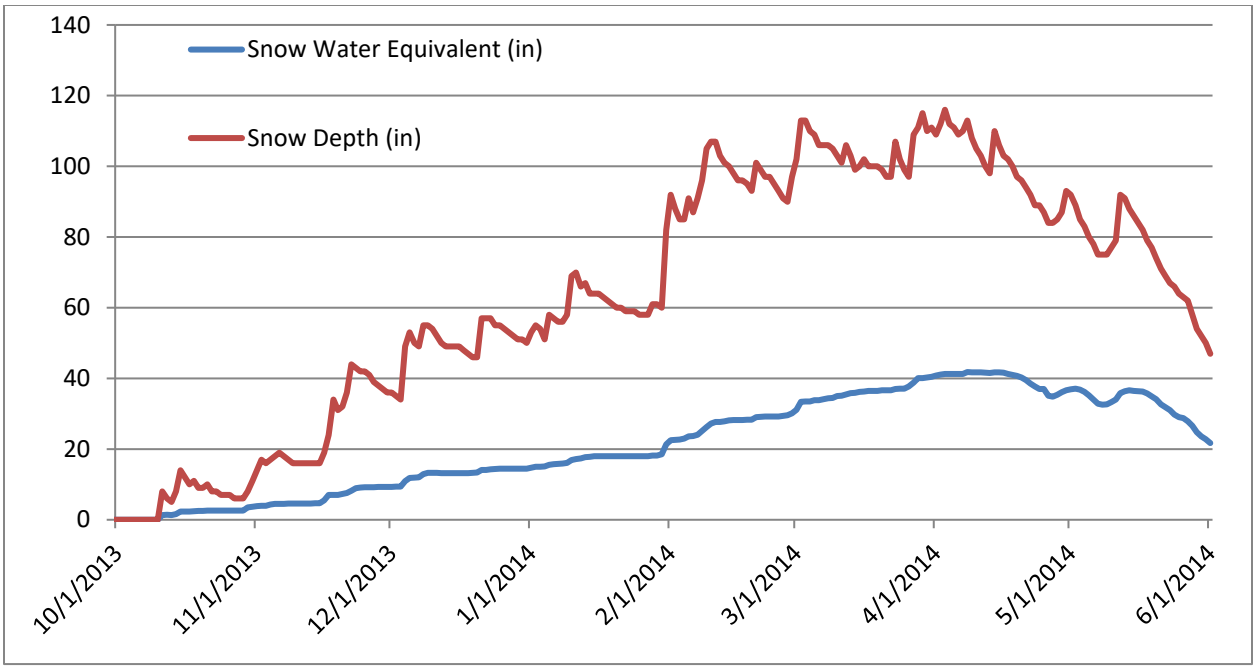

Figure 17: Snow depth and snow water equivalent readings from Schofield Snotel site during 2013/14 season.

The CBAC operated from November 27th through April 13th, and issued 138 daily advisories. The avalanche danger was rated high during 6 days of the early February avalanche cycle, along with 4 other days during the season. Considerable danger was present most of the remainder of February, while Moderate danger prevailed during most of November, March, and April. December and January saw a broader spectrum of danger ratings, with almost a week of Low danger in late January.

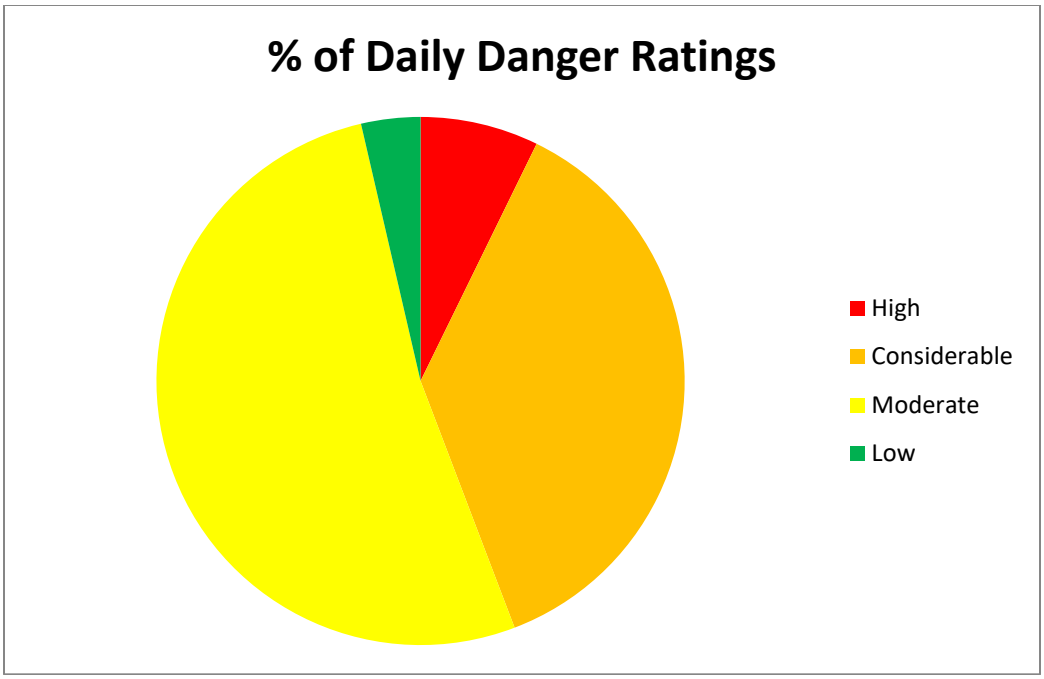

Figure 18: Percentage that each danger rating was present during our forecasting season.

We send our deepest sympathies to friends and families of the one avalanche fatality within our forecast area during this season. A snowmobiler was buried and killed on February 10th along Kebler Pass Road during an avalanche warning. The full report is available at this link: http://avalanche.state.co.us/caic/acc/acc_report.php?accfm=inv&acc_id=523. We received reports of one skier triggered slide involving an injured knee and lost pole, a full-burial roof avalanche, and a roof avalanche that resulted in multiple leg fractures. We thank our community for the constant stream of observations which we rely on for our daily advisories. We published approximately 250 snow and avalanche observations between our forecast team, local guiding operations, our avalanche ambassador team, and community submissions.

Successes, Challenges, and Deep Persistent Thoughts for the 2013-2104 Season

This winter presented a number of challenges and successes for our center, particularly with regard towards the evolving persistent slab and deep persistent slab problems.

Our forecast team used a multi-faceted approach (pun-intended) in issuing advisories to the public to ward off message fatigue. We published and linked to over 170 photos of avalanches and 6 youtube videos (2,732 views) to visually supplement our written forecasts. We also commonly linked to additional resources, such as journal articles, blog entries, or other tools for motivated users get a more thorough understanding. We used our own blog (7,895 views) and published articles in the local newspaper to offer more insight into current conditions. We increased our facebook usage to almost daily posts and continued with our trailhead days, awareness talks, and daily radio advisories to reach a broader audience.

We received a lot of positive feedback from the community for using creative or humorous analogies to describe the deep slab problems or other avalanche concerns. Comparisons to TPS reports, first kisses, work-place flatulence, and more kept our advisories from becoming too stale. For example, our Valentine's Day advisory (at the tail of our major

deep slab cycle), concluded with: “Gentlemen, deep slabs are like your girlfriend or wife today. Give them the special consideration and time they deserve by carefully choosing your terrain and being patient with our snowpack. If you neglect them or forget about them today, you may find yourself getting pummeled by an angry dragon in a struggle to stay afloat.”

This winter, the deep slab problem presented a few head-scratchers from the forecasting perspective. One forecaster from a neighboring zone characterized these challenges well in an email discussion during the February cycle: "This last week was memorable for me. A real highlight in my career. I still can't fully explain some of the slides and conditions I saw. Not many other fields, even in the physical sciences, [have] dramatic events happen and leave you scratching your head or muttering 'Wait, WTF just happened.'"

We saw some very large storms pass with limited or no deep slab avalanche activity, and then surprising deep slabs fail naturally during relatively stable conditions. Our forecasters engaged other professionals, both local and around the country, in insightful conversations and investigated as many crowns as possible to make sense of our conditions. Questions of warming, mechanics, critical loads, and stability tests with regards to deep slabs will still linger into seasons to come.

A common topic amongst our forecast team this year is whether you can have low danger with deep slabs on the problem list. This especially came into play later in the spring when the deep slab problem was very stubborn and human triggering was very unlikely if not impossible, but the threat of an unpredictable cornice fall might be enough to bring down an entire slope. When does very low likelihood trump very large size on the danger scale?

Thanks for a great season! We’ll see you next winter.

Zach Guy and the CBAC team.