Avalanche Forecasting for an Untouchable Snowpack

A meteorological analysis of the events leading to the June 5 avalanche that buried 11 on Mount Rainier's Ingraham Glacier.

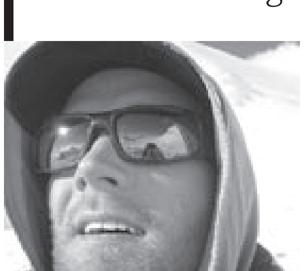
Story & Photos by Kevin Hammonds

This photo of the Ingraham glacier avalanche was taken from a Chinook helicopter in the post-avalanche rescue efforts. A savvy climber can combine 2.76" of SWE in four days from the Paradise Snotel with relative humidity and temp readings from the Camp Muir weather station (10,080', photo below), add in 600 mb pressure levels, and finally, take a quick look at the closest stew-T diagrams to come up with a reasonably accurate interpolation of the snowpack on the upper mountain. This extended June storm in 2010 created dangerous avalanche conditions that impatient climbers were loathe to acknowledge.

The RMI mountain guides who saved 10 of the 11 avalanche victims:

Mark Falender

Adam & Caroline George



Tyler Jones

The phone rang at dawn. The report involved a disastrous avalanche on the upper slopes of Mount Rainier with multiple people buried. On my way to the heli-base, I got my first glimpse of the sleeping giant in what seemed like an eternity – the unrelenting cloud cover had finally moved on. The flanks and rock ribs were blanketed with a fresh coat of snow and shimmered iridescently in the early morning light. Against a deep blue sky there were no visible plumes of snow blowing off the summit like most spring days, hinting at relatively calm winds at the higher elevations. It was obvious that conditions were going to be in favor of a helicopter rescue, probably with the Chinook.

In 2010, summer arrived late to the upper slopes of Mount Rainier. June had turned into "January," and even the marmots seemed keen for summer. The freezing level did not rise above 9000' for any real amount of time until the first week of July, and storm snow accumulations continued to be measured on a scale of feet. Climbers stumbled in and out of the high camps, but few were granted an opportunity for a summit attempt. In stark contrast to the previous summer, when May and June had brought countless summits and ski descents, this not-so-unusual delay of normal spring-like climbing conditions had created a problem that was two-fold. For most climbers, one part was an excessive summit yearning, and the other was a seemingly indignant attitude toward the need for continuing to evaluate a winter snowpack. Although a certain amount of tenacity can often lend itself well to mountaineering in general, this mind-set does not circumvent the abundance of objective hazards on Mount Rainier.

Arriving at the heli-base, we were briefed with the details of the rescue mission: 11 climbers in all had been caught and either fully or partially buried in a dry, soft-slab avalanche. The slide was estimated to have broken out four to six feet deep, run approximately 2000 vertical feet, and scraped clean the entirety of the popular Ingraham Direct climbing route. We were to fly out the most critically injured patients who had already been located and stabilized.

Mountain guides from Rainier Mountaineering, Inc., who witnessed the avalanche from an adjacent area, were the first on scene. Although they were leading a summit climb, they had wisely elected to give their clients some avalanche education in lieu of a summit attempt due to the rising avalanche concern. These guides (named here, as they are unlikely to receive any other formal recognition for their heroism) were Tyler Jones, Mark Falender, Adam George, and Caroline George. Together, they scrambled up the debris pile from below, tugging on every inch of exposed climbing rope they came across in hopes of finding someone attached to the other end. This proved to be an effective tactic, since it turned out that no one was wearing avalanche beacons anyway.

Thanks to the speed of their response, the outcome was not nearly as severe as it could have been. Most notably, one Korean climber who was successfully resuscitated on scene, would not have survived if buried much longer. These four seasoned alpine guides managed to locate, assist, or fully dig out all but one of the 11 victims before additional help arrived. The one still missing, a solo skier who had left from the Paradise parking lot that same morning, has yet to be found and will likely remain entombed somewhere in the vicinity of the Ingraham Glacier.

TOOLS TO BUILD A WEATHER TIME LINE

So, without the local avalanche forecast office up and running, no available surface observations aside from Camp Muir at 10,080', and no snowpit data to look at, how do you determine the avalanche potential of an untouchable and seemingly intangible snowpack? This is exactly what

can make climbing Mount Rainier and similar remote peaks so challenging. Often spurring the early morning ascent known as the "alpine start," is the potential for wet-slab avalanches that tend to occur late in the day. But when considering the likelihood of a dry-slab avalanche, this commonly practiced approach alone is not enough to avoid catastrophe.

To help combat the challenges of forecasting for an unfamiliar environment, in our current day and age of high speed internet, much can be gained from simply building and evaluating a time line of preceding weather events. Because weather-data collection and dissemination has proven to be one of the few successful worldwide cooperative efforts, an atmospheric time line can be built from archived data for nearly any location in the world with only a basic understanding of mountain weather phenomenon. The construction of such a time line can be as simple as a sketch in your notebook or as complex as writing a computer algorithm. The duration of the time line can be as short as 48 hours or as long as an entire winter season depending on how investigative you want to be. The three most important sources providing real measurable data, as opposed to modeled data, are surface observations, atmospheric soundings, and weather maps.

Surface Observations

Surface observations include records from a host of different types of instruments. When evaluating which weather station to use, search for one that is as representative as possible to the area you are going to be traveling in. This would include a similar aspect and elevation as well as position up on a ridge top or down in a basin. Be aware of the effects of the local topography in terms of cold pooling and diurnal winds when performing your analysis. Common measurements useful for a time line include high and low temperatures, wind speed and direction, relative humidity, and accumulated precipitation. It may be necessary to draw from more than one station if these measurements are not all provided at one site. And even if they are, it's still worth comparing trends from one weather station to another. You may need to extrapolate measurements upward or downward if there's not one representative station.

Atmospheric Soundings

Atmospheric soundings display measurements pertaining to the distribution of physical properties within an atmospheric column such as pressure, temperature, wind speed, and wind direction. Essentially, atmospheric sounding data comes from the use of weather balloons, called radiosondes, that are launched on a coordinated schedule simultaneously every 12 hours of every day in varying locations around the world. When surface observations are either not available or not representative – which is often the case in remote mountainous regions – look at the most recent atmospheric-sounding data in the upstream flow of where you plan to be. To help determine the direction of the general flow, use a weather map that depicts the location of the jet stream at the different pressure heights, measured in millibars (mb). For higher elevation peaks, such as Mount Rainier, this can aid you in determining which sets of atmospheric-sounding data are worth looking at and which ones are not.

Weather Maps

In addition to helping determine which atmospheric sounding to use, weather maps can also be useful for both painting a better portrait of previous weather events and forecasting for the future. Archival weather maps can be found for different pressure heights, depending on which is most applicable, and will show former areas of high and low pressure as well as the passage of cold fronts and warm fronts. There are a wide variety of weather maps available online. Some maps have pretty colors and radar overlays, some have surface observations included, and some you more or less need to be a meteorologist to understand. Find and use the map most applicable to your area of interest that best suits your level of meteorological expertise.

ANALYSIS OF EVENTS

The diagram provided by Mount Rainier National Park shows a topographic overview of the Ingraham Direct route and locations where the climbers were thought to be when the avalanche occurred. The starting zone that threatens the Ingraham Direct from above has an upper elevation of 12,800' and an aspect that wraps around from southeast to northeast. The upper-air weather map from June 4, 2010, clearly shows the location of the jet stream, its general direction of flow, and wind speed in knots.

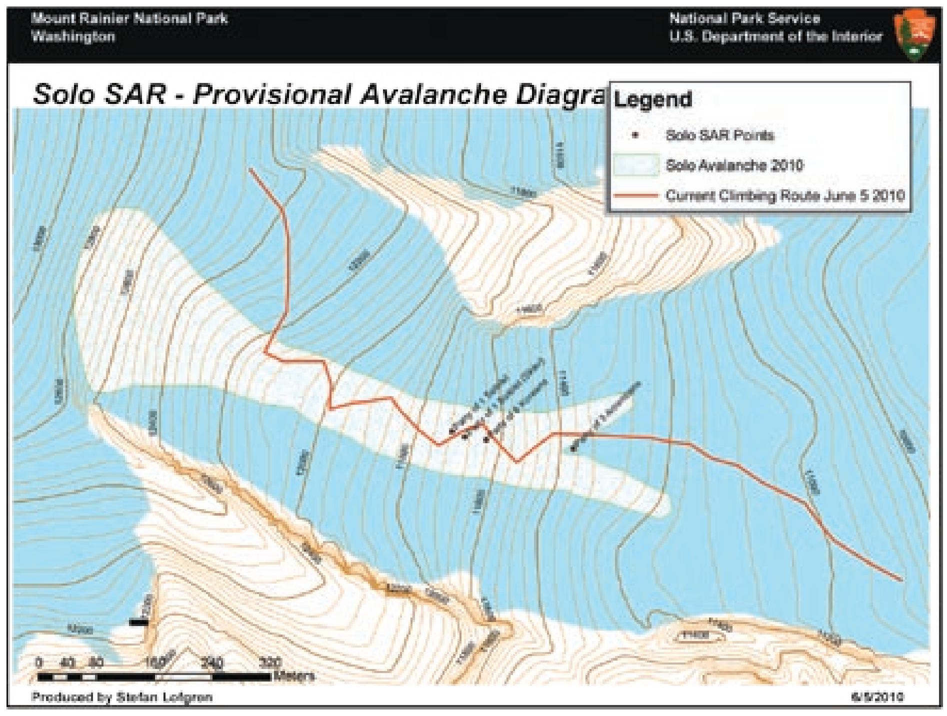
This map was referenced from archival data and is representative of the 300 mb pressure level – about the same elevation as Mount Everest's summit. Although Mount Rainier stands at only half this elevation, around 600 mb, due to the mountain's location near the coast and the lack of any other obstructing terrain, the general flow at the 600 mb level can be considered similar to that at 300 mb. Atmospheric sounding data can confirm or reject this theory. Notice that the general flow of the jet stream as it approaches the Pacific coast is moving over Washington and Oregon from the southwest. Upper-air maps from the previous four days also led to a similar interpretation. From this analysis alone, we can begin to form a hypothesis concerning the potential for wind loading of leeward slopes on the mountain.

Now turning to the best available surface observations – a weather station located at Camp Muir and a SNOTEL site located at Paradise, both of which are on the southeast flank of Mount Rainier – make the most logical choices for representative measurements. The daily maximum and minimum temperatures, relative humidity, wind speed, and wind direction for each of the four days prior to and including the day of the June 5 avalanche were extracted from archived Camp Muir telemetry data. Snowfall totals were then extrapolated from the Paradise SNOTEL data using the formula for Snow Water Equivalent (SWE) and assuming a typical Pacific Northwest 10% density.

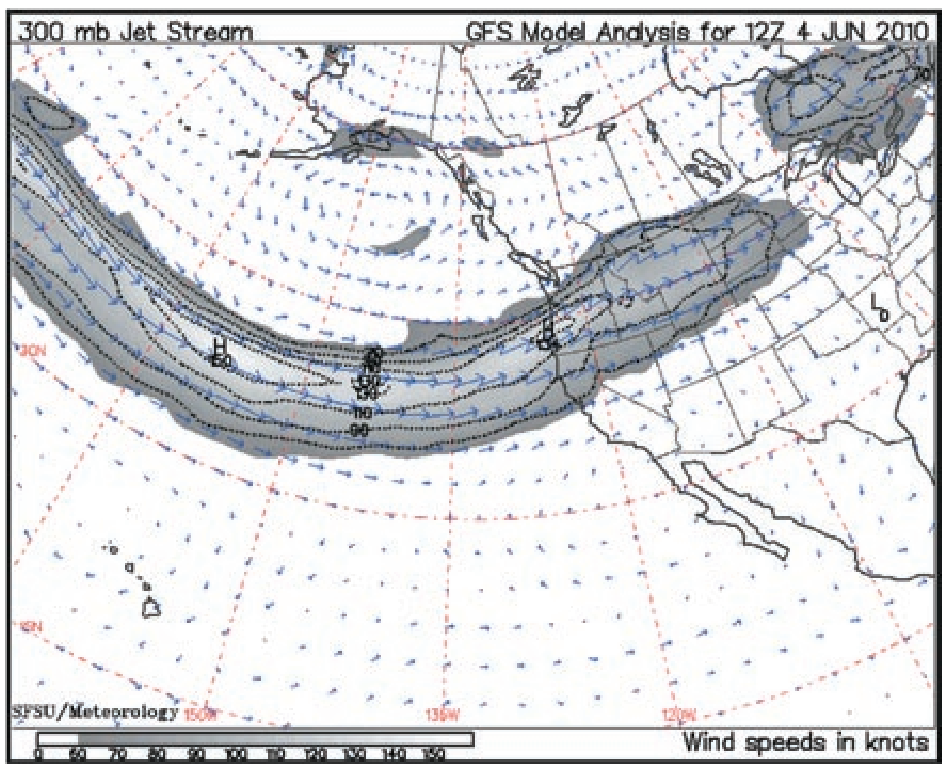
SWE = Snow Depth x Snow Density

In the time period from June 1-5, the Paradise SNOTEL received 2.76" of precipitation. Because it is not unusual for it to be raining at Paradise while sunny and clear at Camp Muir, it is important when making such assumptions about the snowfall amounts on the upper mountain that the relative humidity for Camp Muir, additional atmospheric sounding data, and a 500 mb weather map be taken into account. Congruent with all available data, as well as personal accounts from those actually on the mountain in the days prior to June 5, Camp Muir and above received approximately 2-3' of snowfall. Camp Muir winds were also recorded as strong and persistent from the southwest at an averaged maximum of 40 mph.

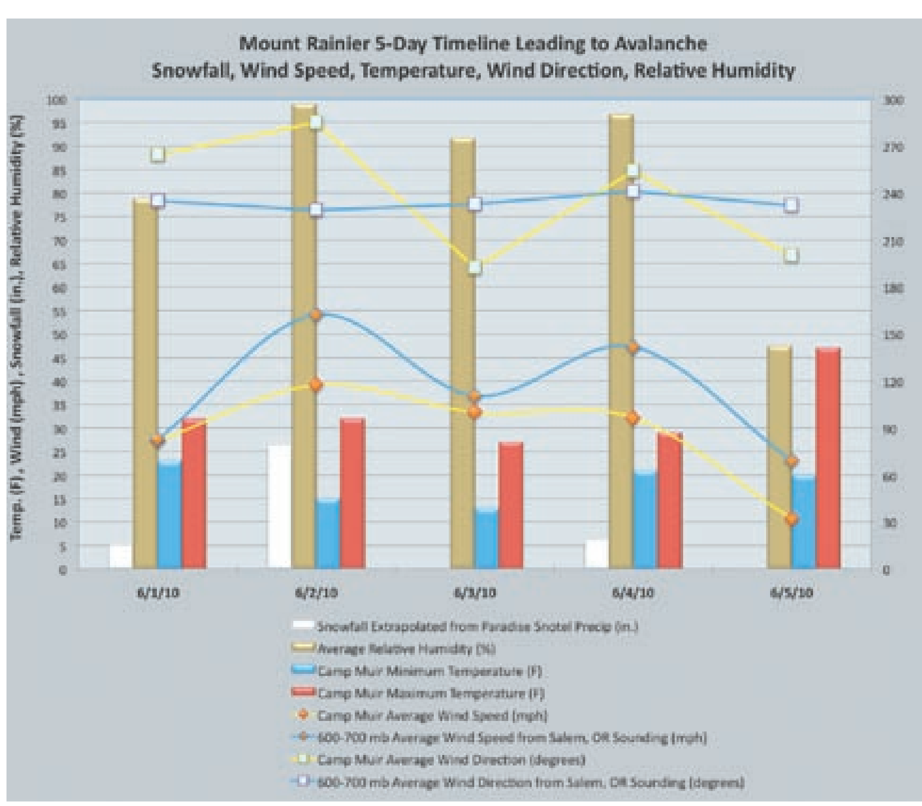
Because the summit of Mount Rainier is at 14,410' while the highest available weather station in the Northwestern region is Camp Muir at only 10,080', atmospheric sounding data can be used to glean further information about winds aloft. With the atmospheric flow already determined to be coming out of the southwest, the Salem, Oregon, atmospheric sounding was used to ascertain average wind speeds and direction for the 600 mb to 700 mb pressure height. The sounding data showed a very similar outcome to that of Camp Muir with very consistent southwest winds but a stronger averaged maximum wind speed of 55 mph.



Map of the avalanche on the Ingraham Glacier, with the climbing route and the location of the buried climbers marked. *Diagram by Stefan Lofgren*



This map of the jet stream from June 4, 2010, shows high wind speeds pointed right at Mt Rainier.



Once the data are all in one place, an untouchable snowpack doesn't have to be an unknown.

CONCLUSION

The time line created to illustrate all the data discussed above, combined with some knowledge of the local topography such as the aspect and slope angle, would indicate a very high probability for significant wind slab development in the starting zone above the Ingraham Direct during this period of time. June 5 was the first real break of a several-day storm, and forecasted high temperatures alone for that day should have been enough to cause most climbers some concern. The exact trigger for the avalanche that buried these 11 climbers remains unknown, but is thought to have been triggered by at least one climber or perhaps the combination of them together. Other possibilities could easily be a cornice drop, the collapse of a serac, or perhaps just natural activity associated with the

Continued on page 32 ➡

UNTOUCHABLE SNOWPACK

continued from page 27

solar radiation from first light. This piece of the puzzle, along with where the solo climber may have been laid to rest, remains a mystery.

To no avail, climbing rangers the evening before had warned climbers at Camp Muir of the hazardous conditions on the upper mountain. But the question is not whether these climbers should have listened to climbing rangers or should have been able to foresee such avalanche conditions on their own. Mountaineering is an inherently dangerous activity, and certain associated risks must be accepted in order to take the next step towards the summit. The real question at hand is whether or not these climbers (or other such climbers under similar circumstances) have at least been exposed to all the resources available to help make the most educated decisions possible. Although there is admittedly much more to factor into the equation than just some data from the internet once you do actually find yourself staring up at a mountain, it has been my experience that such tools can be exceedingly useful in determining the overall disposition of a place before you even arrive. And as it turns out, you do not have to be an avalanche forecaster, meteorologist, or veteran mountain guide to hone this skill – you just have to take the time.

METEOROLOGICAL INFORMATION ONLINE

Surface observations:
mesowest.utah.edu

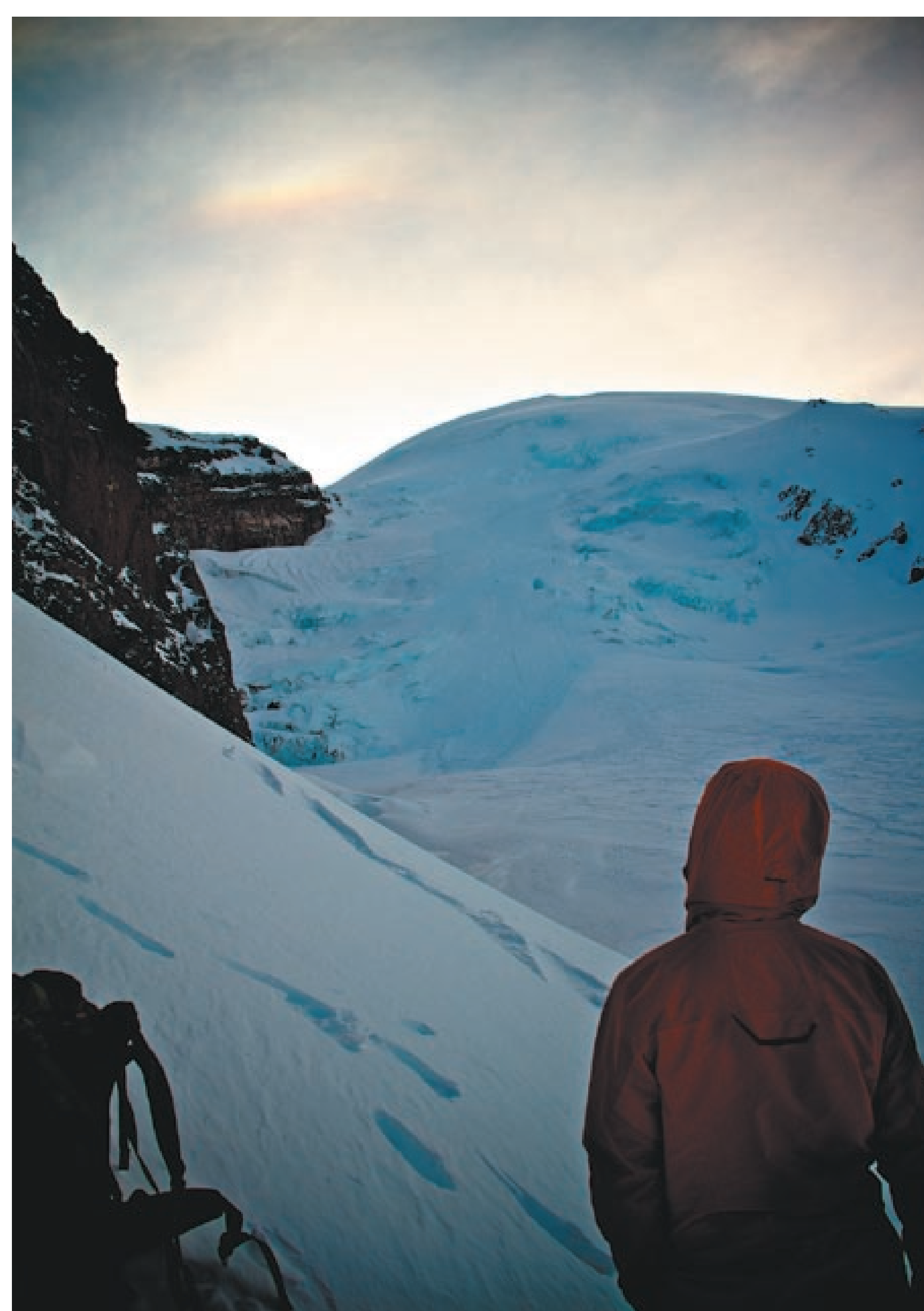
Atmospheric soundings:
weather.uwyo.edu/upperair/sounding.html

Weather maps:
www.intellicast.com

Mountain weather forecasting seminars:
www.mountainweather.com

Weather and climbing route conditions for Mount Rainier:
mountrainierclimbing.blogspot.com

Kevin Hammonds has been a climbing ranger at Mount Rainier for the past three seasons and has just joined the Sylvan Pass avalanche forecasting staff at Yellowstone National Park. He formerly was a member of the Park City ski patrol and the Baker River Hotshots. He will be starting graduate school in the Department of Atmospheric Science at the University of Utah this fall and claims that although he will miss his seasonal lifestyle, he looks forward to facing new challenges and spending more time with his new wife, Kate Meyerhans. ❄



An image from an avalanche on Mt Rainer this past June, where a big cycle this spring caused an incident that involved 11 independent climbers, four of whom were buried, three out of four recovered. One was never located. SS-N-I-R4-D4 *Photo by Jason Thompson, jthompsonphotography.com*