Northwest Weather & Avalanche Center

2000-2001 Annual Report

June, 2001

Report Prepared by Mark Moore, Garth Ferber and Kenny Kramer

A partnership between the USDA Forest Service, Washington State Department of Transportation, Washington State Parks and Recreation Commission, National Weather Service, National Park Service, Pacific Northwest Ski Area Association, British Columbia Ministry of Highways, Friends of the Avalanche Center and others

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SUMMARY AND MISSION STATEMENT

Northwest Weather and Avalanche Center

Mission—

The Northwest Weather and Avalanche Center (NWAC) promotes safety by helping reduce the impacts of avalanches and adverse mountain weather on recreation, industry and transportation in Washington, Oregon and southern British Columbia through data collection, forecasting and education.

To achieve this mission, the NW Avalanche Center:

- assists a variety of snow safety and snow maintenance programs by providing and analyzing useful weather snow and avalanche data, and by producing and distributing a variety of mountain weather and avalanche forecast products.
- assists back country travelers by providing current information on snowpack structure and avalanche danger, and by forecasting expected changes in snow and avalanche conditions.

The professional mountain meteorologists and avalanche specialists at NWAC are on duty from September through June, issuing twice daily forecasts from about mid-November through mid-April.

Summary—

Administration

Since its inception, the NWAC has been administered by the US Department of Agriculture-Forest Service.

Funding

The Avalanche Center is cooperatively funded by a variety of federal, state and private agencies. Important cooperators include the Washington State Department of Transportation, Washington State Parks and Recreation Commission (Snowmobile and Snowpark Programs), National Weather Service, National Park Service, Pacific Northwest Ski Areas Association, British Columbia Ministry of Highways and Transportation, and others.

During it's research phase of operation in 1976-78, the Avalanche Center annual operating costs were ~$81,500, and these costs were shared by WSDOT and The Federal Highway Administration. This provided short summary weather forecasts for three major mountain passes and a short avalanche forecast for about 4 months/year.

In Fiscal Year (FY) 2000, annual operating costs were ~$245,000, and anticipated operating costs for FY2001 are anticipated at ~$247,000 (unfortunately, projected contributions indicate a drop of $20,000 from the Forest Service for FY2002)**. However, the program now provides detailed twice daily meso-scale weather and**

avalanche forecasts for all the Washington Cascades and Olympics, and northern Oregon Cascades—-or together for an area larger than Switzerland. These forecasts are routinely available for 6 months/year, with spot forecasts prepared for the southern BC Cascades and Crater Lake area in Oregon as needed for 8 months/year. NWAC forecasters also prepare daily weather forecasts for WSDOT avalanche control and maintenance personnel for higher pass closure and opening operations in the early fall and mid-late spring. The program also **manages the most comprehensive real-time mountain weather data network in the US**.

The total of Direct (actual revenues received) and Indirect (in-kind) contributions for the Avalanche Center in were ~$348,825 in FY98, ~$378,275 in FY99, ~399,000 in FY2000, and an estimated ~$405,000 projected for FY2001.

The Colorado Avalanche Information Center (CAIC) also provides forecasts and avalanche control / recommendations for the Colorado Department of Transportation (CDOT) for a series of mountain passes. CDOT support of the CAIC program for FY00 totaled nearly ~$267,000.

Housing & Location

The NWAC is housed at the National Weather Service Forecast Office in Seattle, Washington, at the Western Regional Headquarters of NOAA at Sandpoint. The National Weather Service provides in-kind contributions of office space, computer, weather and satellite data access, and dissemination services and has also contributed periodic capital equipment (weather sensors).

Staff

To help minimize cooperator costs, three professional avalanche/weather forecasters are employed for 9-10 months/year, with a fourth forecaster intermittently available for spot forecasting during the winter months. Non-forecast season duties include planning and maintenance of the data network and related services (including web site development), program administration, education, cooperation with program cooperators, and data application of new weather and avalanche technology to meet program goals.

Direct Program Benefits—

Avalanche Accidents and Public Snow Safety

Soaring back country usage during the last 20 years (cross country skiing and then snowmobilers and snowboarders) has produced **an annual average avalanche fatality toll in the United States that has risen from 11 to approximately 27 deaths/year** (5-yr moving average), with 32 fatalities recorded in 1998-99 and 33 in 2000-01— both were unfortunate modern-day records (since 1950).

However, **in the Northwest the fatality toll has and has remained fairly constant at an average of ~3/year** (5-yr total of 16 fatalities for Washington and Oregon).

It is believed that avalanche education and forecasts have resulted in a significant reduction in both avalanche accidents and resulting rescue efforts and costs, hence stabilizing or reducing the number of avalanche fatalities despite major increases in winter back country use and recreation.

There are many documented instances where travelers canceled trips or rescheduled timing or locations of planned trips based on forecast information.

There is also significant documented evidence of popular public response to the program—the NWAC Avalanche Forecast Hotlines log between 10 and 20,000 phone calls annually, with over **1.1 million hits** on NWAC avalanche and mountain weather products via the web during the past year (2000/2001).

Highway and Ski Area Maintenance and Snow Safety

Washington State Department of Transportation claims considerable annual savings through usage of the program.

WSDOT estimated that the **program saved the state approximately $180,000 in 1977/78 and over $330,000 in 1986/87 in direct maintenance costs, lower closure times and reduced public impact**. **More recently, a 1997 WSDOT study indicated that Puget Sound area businesses lose a total of $485,000 per hour of pass closure (for Snoqualmie Pass only).** This means that a total of over 11 million dollars is lost by just local area businesses for every day of pass closure. Such a figure underscores the economic importance of a reliable and accurate avalanche and mountain weather forecasting program. These figures do not include the increased safety margin for highway travelers owing to a more effective and responsive avalanche control and highway maintenance program.

The ski industry (PNSAA and NW ski schools) claim significant benefits in daily area operation, school and work planning, lift operations, and snow safety programs.

Forest Service personnel also allege more efficient maintenance and grooming of popular cross country and snowmobile trails as a direct result of NWAC forecasts.

Education

NWAC forecast staff present a variety of avalanche, weather and snow safety seminars which educate the public and cooperators. During the last 5 years, over 8,000 people have attended avalanche and weather presentations by forecast staff.

Applied Research

Forecast staff constantly tries to apply and advance state-of-the-art techniques in weather and avalanche science. To meet this goal forecasters have attended a variety of training sessions or workshops.

Forecasters have also been instrumental in aiding advances in weather sensors and automated weather sensing techniques, as well as contributing significantly to methodology for avalanche and weather forecast dissemination.

To share these techniques and help expand avalanche and/or weather awareness, forecasters give a variety of presentations at International Snow Science Workshops, the National Avalanche School, and other weather and snow seminars.

Field Data

The NWAC plans, develops, installs and maintains the most comprehensive data network of its kind in the United States. A network of 19 remote automated weather stations (most consisting of at least two or more sub-stations) telemeter hourly precipitation, snowdepth, temperature, wind and relative humidity data to the NWAC.

Data from these stations is automatically linked to the NWAC web site in order to provide both the public (skiers, snowboarders, hikers, climbers and other recreationists) and cooperators enhanced access to real-time weather and avalanche-related data. The NWAC utilizes the mountain weather data to support more accurate forecasts, and cooperators utilize the information for planning, maintenance and avalanche control purposes.

NORTHWEST WEATHER AND SNOWPACK SUMMARY—2000/01

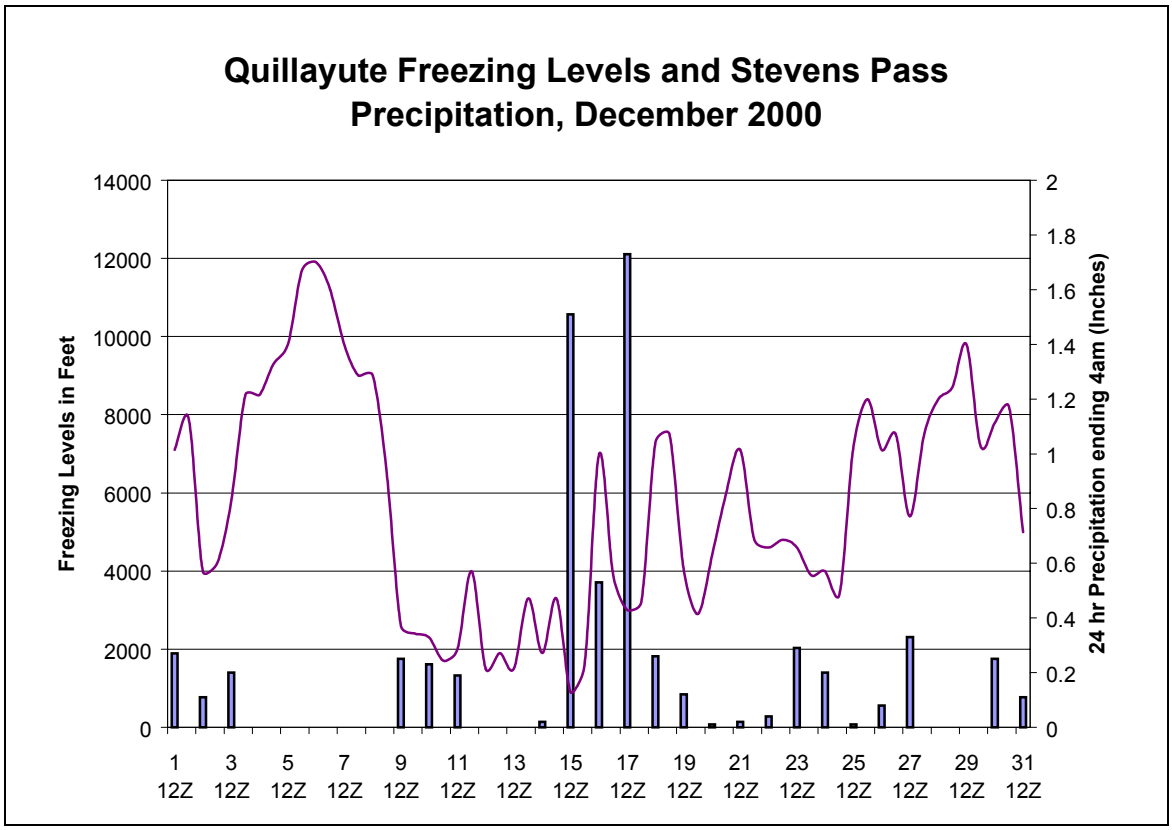
November—

NWAC staff always enter a new season with high expectations for an interesting year of weather and avalanche challenges, successes and yes, a wealth of humbling forecast experiences. This year was no different in these aspects and provided for a memorable year in the US for many reasons, including a new record of 33 avalanche deaths. The snow season in the Northwest really began when a couple of storms arrived in early November and left their mark with a few inches to about a foot of snow, mostly at intermediate and higher elevations. A building upper ridge and a generally cool dry period from about mid November to late on the Thanksgiving Day weekend followed this early season storminess. The cold weather and shallow snowpack resulted in a significant amount of faceting along with some depth hoar near the ground, especially along the Cascade east slopes, near the Cascade passes and on shaded northeast through northwest exposures. Also, substantial surface hoar formed during this period, with reports of hoar frost crystals reaching an inch or more (2-4 cm+). The upper ridge began to break down and move eastward by Saturday, November 25, when the first strong storm cycle of the winter began. A frontal passage deposited some 6 to 16 inches of new snow at moderate elevations. An additional 1 to 2 feet of new snow accumulated over the following two days at lowering freezing levels. This new snow buried the surface hoar and depth hoar in most places, especially on north aspects at higher elevations and along the east slopes.

December—

A very strong ridge in the jet stream then rebuilt over the Northwest, producing a return to generally fair weather during the first few weeks of December (see Figure 1 for a plot of freezing levels and daily precipitation). Many signs of instability within the late November snow were reported with skiers causing instant settling and whomping of the snowpack (as the air was pressed out of lower weak layers of faceted snow or surface hoar) along with shooting cracks. An increasing number of avalanches were also reported, some releasing to the ground (Mission Ridge, Crystal Mountain). A close call came when two back country skiers digging a snow pit in Silver Basin (Crystal Mountain south back country) on 2 Dec at about the 6200 ft (1890m) level triggered and were caught by a large 1 ½ foot climax avalanche. Fortunately no serious injuries occurred with the main effect being high adrenalin levels and some lost gear. Following this event, rebuilding upper ridging (an increasingly common theme this season) brought significant warming aloft on December 5 and 6; however a cold easterly surface flow resulted in a 20 to 30 ^{o}F inversion over the Cascade passes on the 6th. As the high amplitude ridge moved slightly westward and brought a more northerly flow aloft into the region, this allowed for a return to cold temperatures at all elevations during the 2nd week of December and further weakening of an already generally shallow weak snowpack. This also allowed for further surface hoar to develop throughout the Cascades. The return to cold temperatures caused further rapid weakening of the snowpack along the east slopes of the Cascades. At Blewett Pass on the 8th, the entire snowpack consisted of 13 inches of rotten well faceted (recrystallized) snow.

Figure 1. Freezing levels and Precipitation--December 2000



During mid December the second major storm cycle of the season deposited about 1-3 feet of new snow along with strong winds at most areas. From field information received on the 17th, almost all manual observation stations (White Pass, Crystal Mountain, Snoqualmie Pass, Stevens Pass, Mission Ridge, Washington Pass) reported slides involving the old faceted snow near the ground, both from explosive control and skier triggering. The Snoqualmie Pass slide was reported at 3700 feet (1127m) along the Cascade east slopes. At Crystal, some of the large releases to ground on 12/17 were triggered by merely walking along the ridge in Silver Basin and near the King—both to the south of the Campbell Basin chair— with the slides releasing on east to northeast facing terrain. Near Stevens Pass, some slides released to the ground on the back side of the area—generally east-southeast facing slopes.

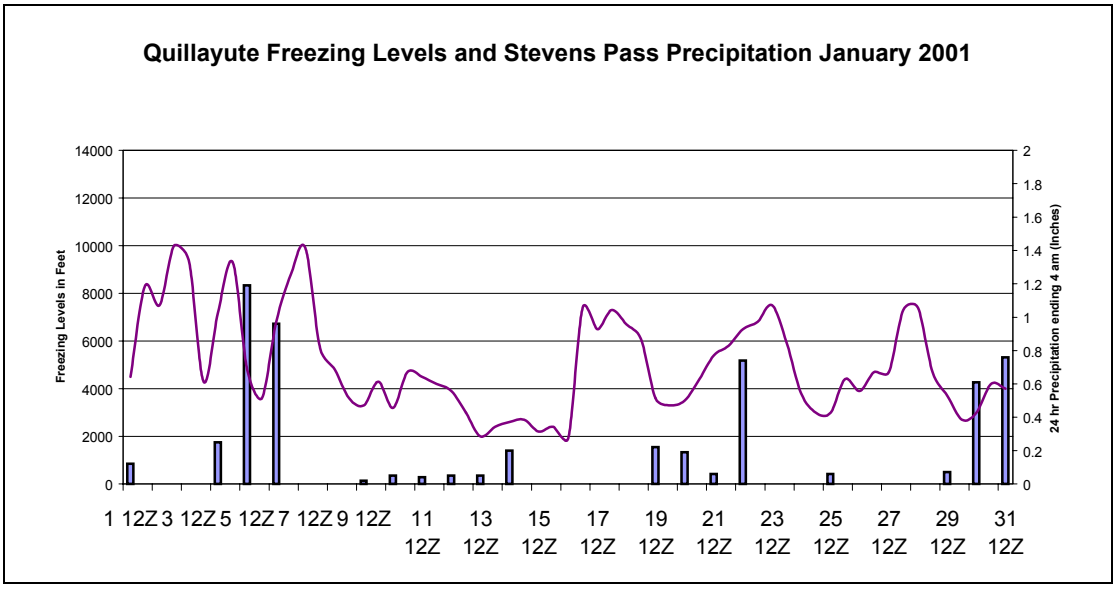
In late December a return to a relatively dry warm ridge over the US west coast brought warm weather with little precipitation. By year end this allowed a strong surface crust to form in many areas and allowed for slow settlement and strengthening of the upper part of the snowpack which began to bridge over the slowly stabilizing old faceted snow near the ground. Still a few avalanches continued to be reported involving the faceted snow near the ground from early in the season, these mainly at higher elevations in the north Cascades and east of the crest. A back country skier digging a snow pit on a southeast aspect at about 7300 feet (2225m) near Blue Peak just south of Washington Pass on December 28th triggered an approximately 500 foot wide, 1 meter deep slab avalanche that released near the ground and ran about 2500 feet (760m) to the valley floor. Fortunately the digger was near the edge of the slab release and was able to crawl over the blocks of the slab and out of the avalanche before it carried him too

far—thus no injuries and a very lucky experience. At Mission Ridge on December 27th 2 children playing on a small north facing slope at about 6000 feet (1829m) triggered a small slab avalanche to the ground. Fortunately at the time of release the children has just left the slope and were looking at the small north facing terrain roll with a patroller when the roll (about a 20ft vertical slope) released and ran onto a flat area just above the top chair terminal.

January—

The new millennium (truly) began where the last one left off. Big ridge. . . dry. . . warm. Mountain temperatures in the 40's and even low 50's (Paradise) in early January? Unheard of? Not any more! The offshore systems moved generally northeastward over the offshore ridge, dumping their precipitation over central B.C. and just brushing the Washington Cascades. Overall this warming (see the relatively high freezing levels shown in Figure 2) allowed the snowpack to gain strength in the Olympics and along the crest and Cascade west slopes as the snowpack experienced significant settlement and temperature gradients became minimal. The warming penetrated through much of the still shallow snow cover (60-75% of normal—see Climate Section below) in places and this helped to both bridge the old faceted snow and slowly strengthen it as well—at least near and west of the Cascade crest. Also, several melt-freeze, rain or freezing rain crusts sandwiched in the snowpack helped to further bridge old weak layers. While these hard layers may have helped to strengthen the snowpack, they did little to help the quality of recreation for skiers, snowboarders, snowmobilers or snowshoers, with relatively dangerous backcountry conditions being reported due to either a breakable trap crust or a smooth hard surface that could produce a "slide for life".

Figure 2. Freezing levels and Precipitation—January 2001



Unfortunately, due to a strong temperature inversion east of the crest, the positive effects of the warming did not affect all areas and much of the snowpack along the Cascade east slopes remained relatively weak and susceptible to the destabilizing effects of loading—if in fact a more normal winter returned in January. . .or February. . or March?

Although a significant storm cycle moved over the area on January 3rd-5th, with 1-4 inches of water equivalent received from Paradise northward, unfortunately much of the precipitation occurred as rain (see also the daily precipitation values for Stevens Pass in Figure 2). Since only minor amounts of new snow had been recently received prior to the event, no significant avalanches were reported and the rain (once it refroze) helped to further strengthen and solidify a near surface crust. Further to the south (south of Paradise), Mt Hood received much less water, thankfully so since with a still shallow snowpack rain was not what they wanted.

Following a split in the westerlies that brought generally minor amounts of snowfall (mainly in the 1-4 inch per 24 hour range) to most areas for over a week, a slightly more productive storm cycle January 13-14th brought 6 inches to a foot of low density snow to most areas, with the most at White Pass and Mt Hood. Loose snow avalanches were reported from White Pass on steeper 40° plus slopes, along with a 6-inch by 300 foot wide soft slab on NE slope at the 6000 ft (1829m) level on Mt Hood.

It was generally dry during the early part of the 3rd week of January as a continuing ridge and split in the westerly flow both diverted and weakened incoming frontal systems. However, this allowed for significant surface hoar growth and continued weakening of the snowpack near the old early January crust, all setting the stage for a significant future increase if just snow arrived. However, several dying frontal systems late in the week brought considerable warm air northward. This warming and associated moisture flowed over a cold easterly surface flow across the Cascades and brought considerable rain or freezing rain to many areas late on the 17th and 18th, effectively destroying most of the surface hoar and mostly bridging over the faceted snow near and just above the early January crust. Finally late in the week and over the weekend freezing levels lowered and mostly small amounts of snow arrived. Fortunately in most areas the bond of the snow to the refreezing wet snow or the freezing rain crust was relatively good—both for avalanche danger and for the potential of recreationists sliding on the crust.

An unusually strong front for this year moved across the area late Saturday and Sunday the 20th and 21st. This brought up to an inch of water at many places (Paradise, Snoqualmie Pass, Mt Hood and Mt Baker) at rising freezing levels. With the new increasing density snowfall landing on the smaller amounts of weaker new snow received the previous week, numerous explosive and skier triggered soft slab (SS) avalanches were reported early Sunday before snow changed to rain. Rain then reached about 5000 ft near Mt Baker and to 7200 ft on Mt Hood, and subsequent cooling helped to lock the recent snow in place after the wet snow began refreezing Sunday night.

The snow surface refroze early during the week of the 21st along with additional very light accumulations of 2 to 4 inches from deformation bands moving northward in a continued split flow. Except for some shallow wind slabs and a moderate danger that developed mid-late in the week above 5 to 6000 feet, in most areas just a few inches of low-density snow lay over the strong crust resulting in a low danger. Mt Baker received somewhat greater new snow, and some 15 to 20 inches were seen over the crust. However, in most places even here the new snow arrived with very little wind and was not cohesive, therefore only a minimal increase in danger resulted. With a rex block (upper closed high over an upper closed low) forming mid-

late in the week after another split trough moved through the region and closed off over California, an associated dry east to northeasterly flow produced clearing skies and mostly fair cool weather Friday and Saturday, the 26th and 27th. This was reinforced by another short wave ridge that helped maintain generally dry weather through mid-Sunday, the 28th. These weather conditions allowed for several important developments both on the snow surface and within the snowpack, namely considerable hoar frost, thin surface sun crusts and continued faceting and weakening of the snow pack both near old crusts and the ground in areas having a very shallow snow cover. These developments generally provide the potential for both a rapid increase in the danger from new snow instability (sensitive slabs overlying the surface hoar), but also allow for an increased potential for larger climax slides to the ground if prolonged heavy loading occurs—which looked likely to the forecasters during the week ahead (Jan 29-Feb 2).

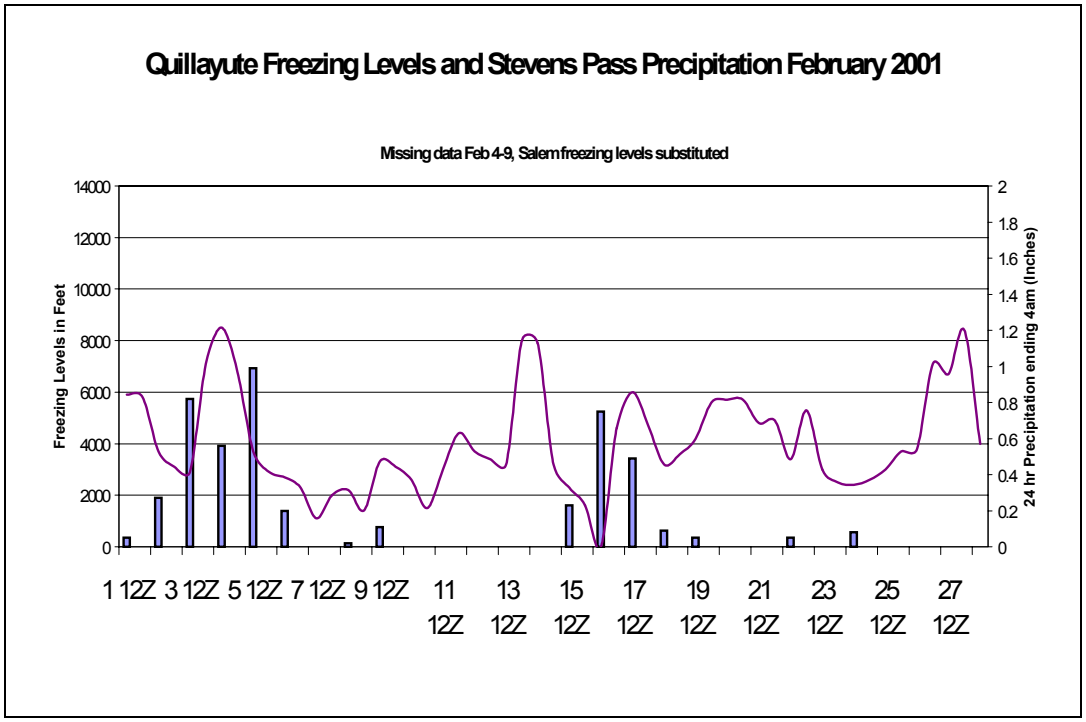
In fact, considerable loading actually arrived late Sunday through early Wednesday the 28th–31st. Snowfall with varying temperatures and strong winds produced sensitive slabs over the previously mentioned weak layers over the crusts. Numerous slides, both natural and human triggered, were reported later Monday through Wednesday (the 30th and 31st) along with several avalanche accidents (see the details on the NWAC web site (www.nwac.noaa.gov) or summaries below in the Accidents Section). Forecasts issued on the 28th and 29th both focused on the overall and expected increase in the avalanche danger, and avalanche warnings were issued by NWAC on both the 30th and 31st. Unfortunately as the accidents demonstrated, not everyone was as prepared for or as aware of the potential for an increased danger as might have been hoped. Some isolated slides also released to the ground at Crystal Mountain. These climax slides released primarily on slopes that had previously slid to the ground earlier in the winter. However, most ski-triggered and controlled avalanches were 12 to 24 inches and failed on a thin sun crust formed the week before or they collapsed down to a more deeply buried melt-freeze crust formed during the rain of mid-January (actually either the 18th or the 21stdepending on location).

February—

Following a rather dismal and meek January, February arrived like gangbusters promising a return to winter. . .unfortunately it also fizzled just as fast. Several strong weather disturbances moved into the region from the 1st through the 4th of February, depositing some 1 to 2.5 inches of water and 18 to 36 inches of snow. Initially the avalanches were confined to surface layers on control, however a warm up and rain on the 4th produced a good avalanche cycle with numerous natural and triggered slides which involved some of the snow down to some faceting above the mid-January crust. This potential for slides running more deeply than expected (deeper than the most recent storm deposited snow) surprised a patroller near Crystal Mountain who triggered a 3 ft slab that ran on faceted snow above an old crust. Fortunately he was able to slow his descent through trees and was on the surface—mostly uninjured—when the slide stopped. Cooling with very light amounts of snow followed on the 5th through the 8th of February with only a few more inches of snow accumulating. A return to a blocking ridge pattern produced dry clear and increasingly cold weather along the Cascade east slopes and at lower elevations on the 9th through the 14th as a cool easterly surface flow developed across the Cascades (see the relatively low freezing levels and lack of precipitation during this period in Figure 3). During this time significant surface hoar growth occurred; however warming aloft and strengthening sunshine also produced sun crusts and melt-freeze crusts as air temperatures

climbed to the low 40's in many areas above the cool easterly surface flow through the passes. No avalanche activity was reported other than a climber released slab on Mt Rainier at about 11,500 ft (3505m). Though two climbers were caught they luckily self arrested, were only partially buried and received only minor injuries.

Figure 3. Freezing levels and Precipitation—February 2001



While the Northwest weather on the 14th and 15th continued to be dominated by weak northerly flow around a closed upper high in the Gulf of Alaska and a weak westerly flow into California under the block, this did allow a cold air mass to settle into eastern Washington—ready to stream over the Cascades into the western Washington lowlands as pressures lowered in advance of an approaching front late on the 15th. Following a very weak disturbance in the still mainly northerly flow over the area that spread further cooling and a few inches of very low density snow southward on the 15th, the associated upper trough and surface low intensified as they began to merge with a closed low developing in the southern part of the split. This intensification circulated increasingly warm moist air northward late on the 15th through early on the 16th. The moisture quickly overran and was lifted by the continued cold air at the surface, producing a significant snow storm in the lowlands of western Washington. While the associated southeasterly winds also produced some heavy snowfall in the south-central Cascades and Olympics, along with strengthening winds and slow warming, all of this resulted in development of increasingly unstable wind slabs overlying and poorly bonded to a variety of weak snow layers including old melt-freeze crusts, surface hoar and some weak low density snow that had fallen early Thursday (the 15th). The resultant unstable snowpack prompted the first avalanche warnings in some time along with avalanche control closures at both Stevens and Snoqualmie Passes on the morning of the 16th. The avalanche danger increased to high above 3 to 4000 feet and both passes reported good control results and

1-2 ft slides running long distances—reaching and crossing the highway. Similar sensitive slabs were reported in the ski areas, with the most sensitive snowpack reported near Crystal Mountain. At Crystal, 19 inches of new was reported on the morning of the 16th, and some large slabs were released sympathetically on steep terrain by patrollers walking along a nearby ridge. While the continued low temperatures during most of the snowfall helped to keep slab densities low and not overload the still relatively fragile and faceted snowpack near several buried crusts, NWAC forecasters remained uneasy about the continued potential for large loading events producing large slides down to these old weak snow layers.

Subsequently, several avalanche accidents occurred on the 17th due to these conditions. The second Northwest avalanche fatality of the season occurred from a snowmobiler triggered slab near Van Epps Pass above the Salmon La Sac drainage east-northeast of Snoqualmie Pass. The second accident of the day occurred near Crystal Mountain when a skier ducked under area closure ropes and triggered a 4 foot slab crown on an east-northeast aspect. The ensuing slide resulted in a broken arm and severely bruised or broken jaw for the unlucky closure violator.

From the 18th through the 22nd the Northwest weather reverted to its normal relatively dry pattern for this year as a split flow dominated the jet stream offshore. Although the strong southern branch flow around the offshore rex block low (another upper high in the Gulf of Alaska over a closed low to the south) produced heavy snowfall in the Sierra Nevada, further north a weak band of moisture rotating around the low deposited generally minor snowfall amounts ranging mostly from 1-3 inches in Washington and 4-6 inches in the Mt Hood area. This new snow fell on an old wind slab in the Mt Hood Meadows area near Heather Canyon and along with some wind transport by moderate south to southwest winds resulted in some shallow 4 to 6 inch wind slabs. Several ski patrollers triggered shallow slabs near the canyon around the 7000-7500 ft level and two skiers also triggered a shallow slab from the 7500 ft (2286m) level on Thursday, the 23rd. This incident was caught on video by nearby recreationists and the tape was subsequently made available on KGW-TV station's web site. Hopefully the footage helped to emphasize that even with a moderate danger avalanches and avalanche accidents are still possible, especially if someone ventures onto steep wind loaded terrain. In this instance, the skiers had ample evidence of the instability, as several nearby slopes had already been triggered by patrollers earlier in the day and on Wednesday. Away from the Mt Hood area however, warm daytime temperatures in the upper 30's and 40's helped to settle new snow and form melt-freeze or sun crusts in many areas.

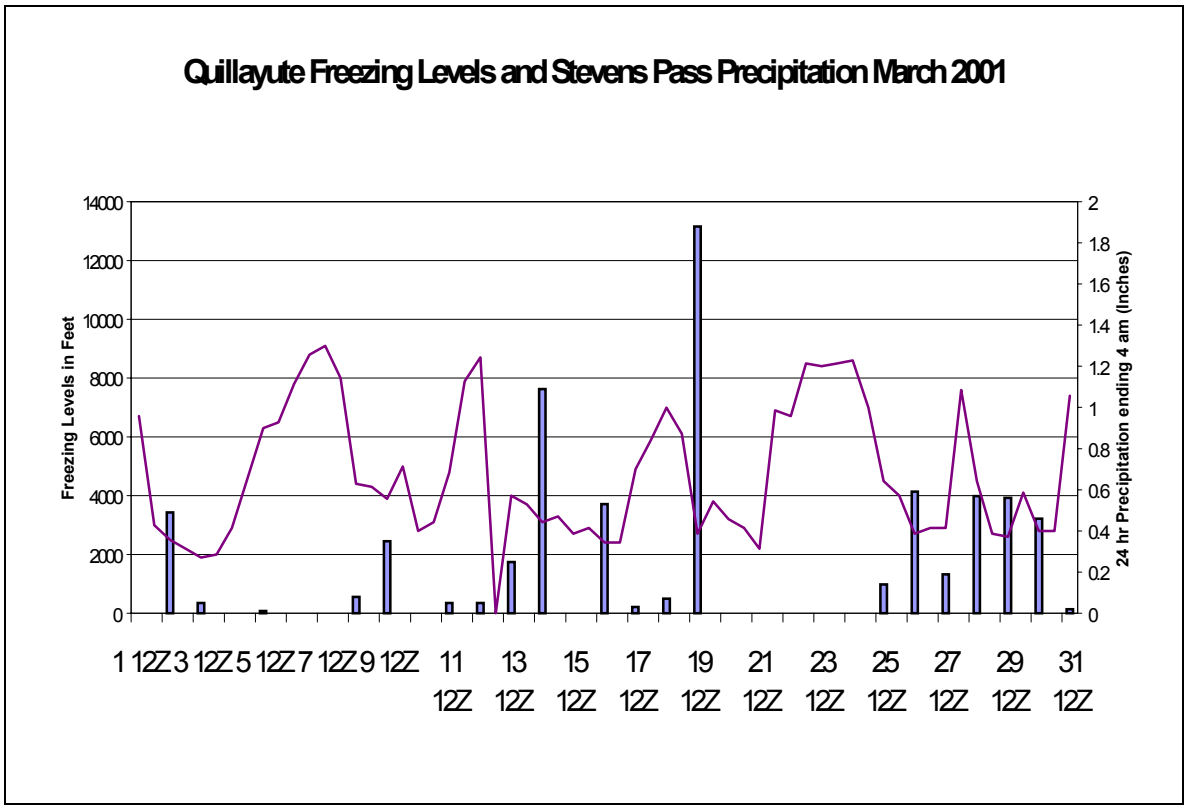
The split flow continued to direct most incoming storm energy well to the north or south of the region on the 24th-26th with mostly sunny skies and slow warming on the 25th and 26thof February. While this allowed for a further decrease in the danger at lower elevations and on sun-exposed terrain through settlement and increasing surface crust formation, it also allowed for increasing surface hoar to develop over a variety of snow surfaces including the developing MF (melt-freeze) crust, previous shallow new snow or old wind slab surfaces.

March—

Finally, late in February the ridge briefly broke down as the recently dominant rex block (upper high over closed upper low) weakened and moved eastward. This allowed a quick but significant intrusion of moderate to strong westerly flow over the area in early March, and most

locations near and west of the Cascade crest received from about 6 to almost 20 inches of increasing density wind slab over either the recent crust, low density snow or pockets of surface hoar. Field reports indicated that the bond of new snow to the existing snow surfaces was not particularly good, and several areas experienced significant 1-2 ft wind slabs releasing easily and running relatively long distances. However, winter left just as quickly as it came, and by the 5th and 6th of March, a healthy rex block reestablished over the area with heavy precipitation again returning to California. By this time of the winter—March 6th, Los Angeles had received over 16 inches of rainfall since January 1st while "rainy" Seattle had received 1/3 less—only 5 inches. As the upper ridge intensified over the Northwest on the 6th and 7th, freezing levels and air temperatures skyrocketed to nearly 10,000 ft and the upper 40's and 50's, respectively. This produced considerable melt, weakening and stress within the recently deposited snowfall, and a significant loose and wet loose slide cycle occurred on many steeper slopes during daytime warming on the 6th and 7th, along with several small skier and cornice released slabs on more shaded terrain.

Figure 4. Freezing levels and Precipitation—March 2001



Once again the familiar rex block and associated ridge directed storm energy anywhere but the Northwest into the 8th, along with relatively high freezing levels and more surface crust formation. Even though a weak disturbance penetrated the ridge and moved over the region later Thursday morning and early afternoon on the 8th, relatively light snowfall of 2-6 inches was reported in most areas except for Stevens Pass where up to 11 inches was received in a weak and brief convergence zone. However, most of this was received at cooling temperatures with generally light to occasionally moderate winds, thus minimizing the increase in danger

immediately following the storm. Several days of clearing then helped settle any lingering wind slabs and produced increasing crust formation in most lower elevation and on sun exposed terrain. However, daytime warming also produced some natural loose and wet loose slides on steeper terrain. Several weak splitting disturbances then penetrated through the split flow to give occasional light rain or snow at slowly rising freezing levels to most locations from the 10th through the 13th. This produced another minor loose or wet loose surface slide cycle. A slightly stronger disturbance moved over the region on the 14th and gave snowfall ranging from 4 to about 8 inches. Increasing moderate winds with the system produced areas of increasing wind slab on several exposures and a considerable danger above 4 to 5000 feet, mainly near and west of the Cascade crest where heaviest orographic snowfall was reported. Although another weak ridge brought briefly decreasing snowfall late on the 14th and into the 15th, a weak to moderate surface front and associated trough moved into the area on the 15th, bringing occasionally moderate snow and only slightly rising freezing levels. With several more significant storms expected over the weekend in what the models forecast as a strong westerly flow over the top of a flat ridge, the stage was being set for a significant increase in the avalanche danger. Slowly rising freezing levels, moderate to heavy precipitation and increasing winds likely late Friday and Saturday followed by another strong system on Sunday, the 18th , ensured the first avalanche warning situation in some time as increasingly dense snow or rain was likely to overload lower density colder snow deposited Wednesday, Thursday and late Friday. As it turned out much of the energy with the first storm was diverted northward into south-central BC, with generally minor precipitation amounts and mostly rain received on the 17th along with gradually rising freezing levels. However, the next system expected on the 18th indeed proved to be much stronger, with moderate to heavy rainfall of generally 1-2+ inches spreading to above 5000 feet in the north and over 7000 feet in the south. This prompted issuance of an avalanche watch on the 16th (high danger at or below 4000 feet in Washington and 5000 feet in the Mt Hood area greater than 24 hours in advance). Avalanche warnings were then issued on the 17th and again on the morning of the 18th. While visibility was generally very limited during the heavy precipitation in most areas on the 18th, there were sporadic reports of some wet loose and isolated wet slabs. Following the heavy rainfall, rapidly and substantially lowering freezing levels occurred on the evening of the 18th. However, although much colder temperatures and substantial winds were received the earlier forecast moderate to heavy orographic snowfall never really materialized. Except for minor new snow accumulations of about 4-8 inches in the north Washington Cascades, little or no new snowfall was received elsewhere. This resulted in a dramatic lowering of the avalanche danger with low danger in almost all areas developing during the late night and early morning hours of the 19th as skies cleared and precipitation essentially ended after the front. Slowly building offshore ridging ahead of a closed low in the central Pacific slowly lifted the old low now over northern Canada northward, and the associated once proud and stronger westerly flow slowly diminished and dried. Hence once again the Northwest returned to its now normal lovely blue skies and abysmally shallow snowpack for much of the last of winter and first few days of spring (essentially from the 19th-23rd). This allowed for a relatively early opening of Washington Pass on the 22nd. However, with the new snow from the 18th and 19th being warmed by sunshine on the 23rd, several loose and wet loose slides produced intermittent brief closures during the warm afternoons while WSDOT crews cleared the new debris from the inside highway lanes.

The weather finally changed toward a briefly stronger westerly flow over the weekend of the 24th and 25th. Unfortunately this was also a relatively warm flow that brought light to moderate rain to higher elevations on Saturday with a little light snow accumulating on Sunday, the 25th. A slightly stronger system in a continuing moderate west to northwesterly flow brought further snowfall to lower elevations on the 26th and early on the 27th before being mostly washed away by moderate to heavy rainfall of 1-1.5 inches on the afternoon and evening of the 27th. This rain brought an increased danger and some wet loose and isolated wet slab slides along with some climax slides at lower elevations where the snowpack was becoming increasingly wet and weak in places as the old faceted snow near the ground from early in the season became wet and rotten—especially near steep smooth rock faces below about 4000 feet. Several of these climax slides were seen in the Alpental Valley along the access road and up valley toward Source Lake below 4000 feet. At higher elevations, heavy dense snow above about 4 to 5000 feet in the north and above 6-6500 ft in the south loaded recently deposited weaker lower density snowfall received on the 26th, and this brought an increasing danger from some 1-2 ft wind slabs at higher elevations. Also several glide cracks began expanding on some steeper terrain at lower and intermediate elevations with the rain—perhaps a precursor of larger slides to come. Lowering freezing levels and light rain changing to snow along with moderate ridgetop winds began to build further small wind slabs on the 28th, with expectations of further loading by a moderate frontal system on the 29th. New wind slab deposits formed by high winds of 30-50+ mph in some areas resulted in a considerable danger above 4 to 5000 feet in the north and above 6000 feet in the south. The next moderate frontal passage overnight on the 29th deposited an additional 3 to 6 inches of new snow along with very strong westerly ridge top winds as most exposed ridgetop wind sensors reported gusts of 50 to 70 mph. Mark and Garth were at Stevens Pass on the morning of the 30th to witness the widespread, sensitive skier and explosive released soft slabs of mostly 8 to 12 inches within the area. Our roving avalanche eyes also spotted numerous natural loose or wet loose slides releasing when sun reached the slopes late Friday morning, as is typical when fresh snow sees the sun for the first time following spring snowstorms.

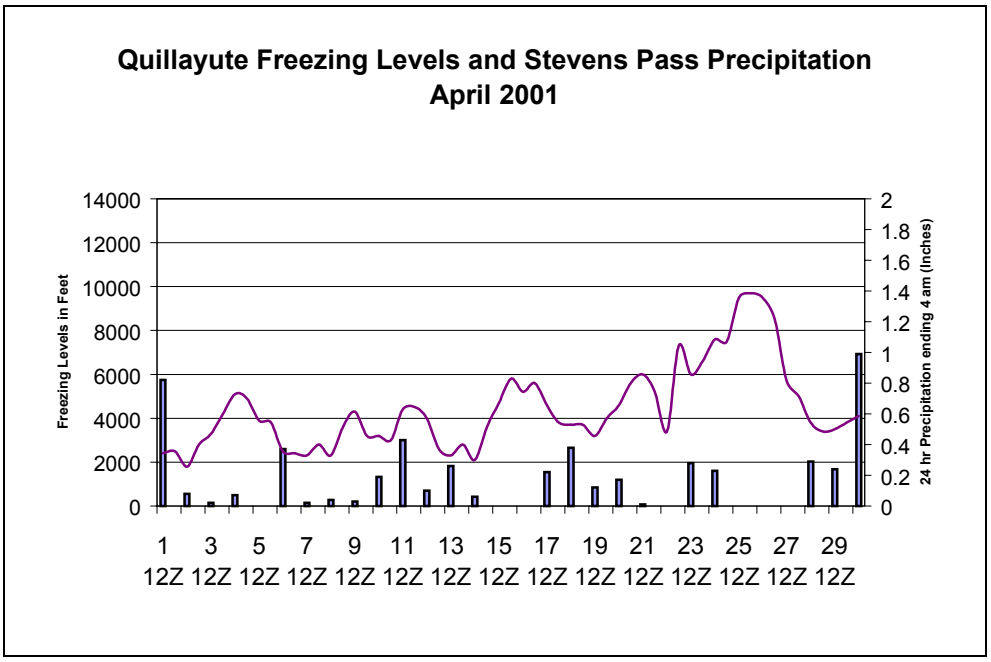
March ended as a briefly moderate westerly flow carried a front across the area on the 31st. This produced rain up to about 5000 feet in the north Cascades and to about 6000 feet in the south Cascades and Mt Hood area. About ½ to 1 ½ inches of precipitation, mostly as rain was seen west of the crest. Very little snow followed the front and cooling caused the previously rain-wetted snow to form a stable crust. A few inches of snow were seen at higher elevations in the north Cascades, where a few isolated surface slab layers were possible. But most areas reported only light amounts of snow deposited over the stable crust by April 1st.

April—

A light rain/snow mix greeted the Northwest in early April (the 2nd) during what was to become a relatively stormy and winter-like month. This was followed by a closed low on Tuesday the 3rd that produced considerable return or wrap-around moisture along the Cascade east slopes with 6 to 10 inches of new snow reported along the east slopes (both from Washington Pass and Mission) and briefly unstable soft slab conditions witnessed by skiers near Washington Pass (where small avalanches partly blocked the highway during stormy weather on the 3rd of April,). Otherwise near and west of the Cascade crest, the weather remained relatively dry the 4th through mid-day on the 5th, with only very light new snow accumulations. A moderate front

moved through the region Thursday night the 5th for more snow and winds at relatively low snow levels. This produced an increase in the danger as some new wind slabs developed near higher ridges and new moist snow at lower elevations became susceptible to the destabilizing effects of daytime warming and sun breaks between showers. The associated closed upper low moved slowly southward through the region on the 6th-8th to produce additional new snow accumulations of 6 to 14 inches at continued low freezing levels. Some small wind slabs developed on a variety of exposures above about 5 to 6000 feet, but most instability developed as a result of daytime heating and solar warming, melt and weakening of new surface snow between showers.

Figure 5. Freezing levels and Precipitation—April 2001



Several more significant storms moved over the region during the second week of April, one arriving in a northerly flow and developing significantly as it moved southward over Washington. Increased westerly flow ahead of this low brought locally heavy snowfall to the Cascade west slopes while strong northeasterly flow behind the low brought heavy snowfall to the Cascade east slopes (from 8 to over 14 inches of snow was received). The very strong north to northeasterly winds behind the tight upper and surface low produced considerable wind effects on the local snowpack, with some exposed north and northeast facing terrain scoured down to a melt-freeze crust from early in the week while a few feet away on the lee south and southwest exposures hard slab conditions developed. On these lee slopes high density wind slab deposited over lighter lower density snow falling early in the storm produced a very hollow feeling snowpack with 1-2 ft slabs reported in several areas. This unstable snowpack structure produced the third avalanche fatality in the Northwest this winter season on Wednesday, the 11th of April. Following the big storm on Tuesday, the ensuing northerly flow brought clearing skies overnight and Wednesday dawned clear and beautiful, luring a number of folks out into the late season powder. Unfortunately, powder existed at lower and wind sheltered areas, but hard slab conditions existed on more exposed higher terrain. And a snowmobiler highmarking a

south facing slopes at about the 6600 ft (2012m) level above Schreiber Meadows enroute to Mt Baker triggered a 2-2.5 ft hard slab that released over 1/3 mile across and carried the victim some 6-700 vertical feet. Although several other snowmobilers witnessed the accident, the victim did not have a beacon and was not found until late that afternoon (about 7 hours later) when an organized probe line found him under about 3 to 4 feet of snow. During this time of increased danger, a larger avalanche completely blocked the Washington Pass Highway (SR20) on the evening of April 10th .

Another storm from the west undercut a weak ridge and moved into the region later that week (the 12th-13th), bringing an additional 6-10 inches of snow at continued low freezing levels. Although a lot of powder was reported, periods of strong winds during the storms also brought increased avalanche activity on a variety of slopes from both wind slabs and small loose slides that released from warming following the storms. By the weekend of the 14th and 15th, some 2-5 feet of new snow had accumulated at intermediate and high elevations, and the normal mid-April closing time of the Avalanche Center quickly became a distant memory. Considerable to high danger developed over the weekend of the 14th and 15th as gradual warming accompanied a weak split flow with variable high clouds helping to enhance the effects of filtered sunshine on south facing slopes. This warming produced slow settlement of recently unstable slabs but also melted and weakened near surface snow, producing initially small loose, wet loose and isolated slab slides that gradually entrained and gouged into deeper moist surface snow as the warming continued. The warmest day thus far in the spring arrived on the 16th of April, with freezing levels rising to about 6000 feet over the north Cascades and about 7500 feet in the south, along with plenty of increasingly strong solar radiation. Numerous wet snow avalanches were reported by WSDOT avalanche crews at both Chinook and Washington Passes, including some that temporarily blocked the highway at Washington Pass.

Following the warm day on the 16th a series of relatively strong weather disturbances moved over the area late on the 16th through the 22nd, bringing increasing snowfall at prolonged and unusually low freezing levels for late April. This brought additional new snowfall ranging up to 12-18 inches above the 4 to 5000 ft level, with greatest amounts from about Mt Rainier northward. Along with considerable wind transport, this created significant cornice formation and unstable slabs on northeast through southeast exposures, with considerable danger occurring on lee slopes throughout much of this period. While less new snowfall occurred at lower elevations, the wet new snow that was received generally needed little or no disturbance to slide and during any sun breaks between showers this new snow began to peel off rocks and tree branches, sometimes releasing wet loose or loose slides on the slopes below. During almost every clearing period, field reports indicated increasing natural avalanche activity from just such a scenario as new snow warmed, melted and weakened by sunshine or daytime warming spilled off trees and steeper cliff bands.

Finally, true spring weather really did arrive on Monday, the 23rd and a substantial warming trend continued into early Thursday the 26th with the highest freezing levels of the year. Mountain top air temperatures reached into the 50's to 60's at most locations at the 5-6000 ft level on Tuesday and Wednesday (the 24th and 25th) with freezing levels rising to 10-12,000 feet. Wet snow avalanches during this time temporarily closed the North Cascades Highway at Washington Pass (24th), and were also seen at Stevens Pass, Chinook Pass and near Paradise.

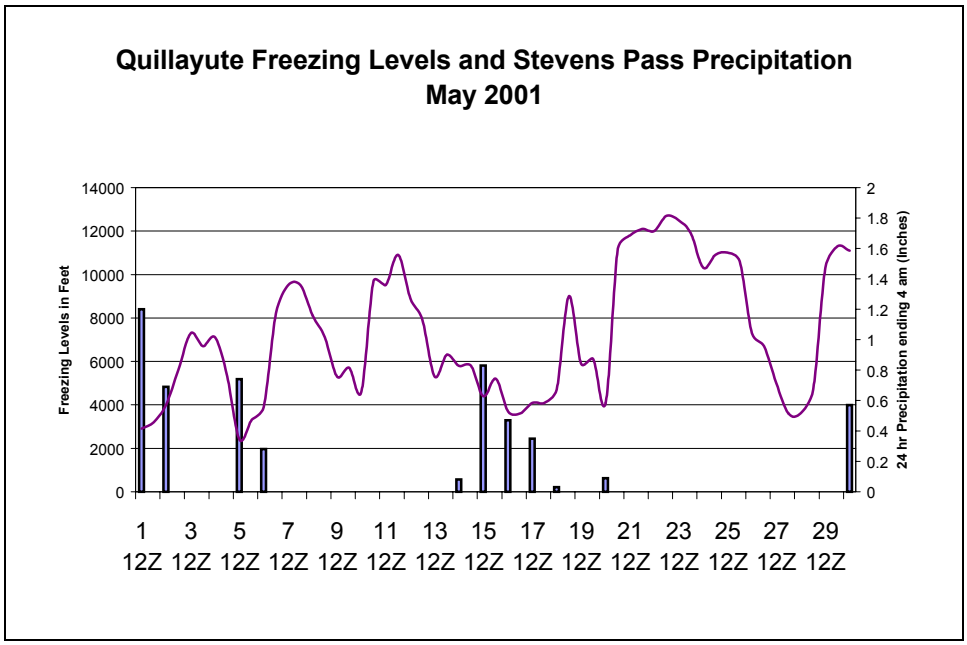
Rather large crowns from slab avalanches were also noted across from Paradise on north slopes in the Tatoosh Range and a 6-8 ft climax slide to the ground was reported releasing on Kangaroo Ridge near Washington Pass, running some 2-3000 vertical ft to the valley floor.

Following the significant warm-up an unusually strong late April jet stream of 120-130 knots in the eastern Pacific settled in over Washington and northern Oregon from the 27th of April through the 1st of May. This brought gradually increasing precipitation, slowly strengthening winds and lowering freezing levels late on the 26th and 27th, with increasingly heavy precipitation, strong winds and relatively low freezing levels on the 28th-May 1st, when new snowfall amounts ranging up 30 to 40 inches were received above the 4 to 5000 ft level. Along with ridgetop winds reaching 40-60 mph on the 29th and 30th this produced increasingly large wind slabs up to 3 to 5 feet on some northeast through southeast exposures. This also produced seasonal snowdepth maximums at several high elevation stations (Paradise—143 inches, Mt Baker—126 inches, White Pass upper plot—95 inches, Stevens Pass Skyline plot—94 inches).

May—

While regularly scheduled avalanche and mountain weather forecasts finally ended on the 29th, the strong spring storms of late April and early May prompted NWAC to issue a series of special avalanche statements throughout the week of April 30th-May 5th. As the strong upper trough of April 28th-May 1st was gradually replaced by strong upper ridging on the 2nd-4th of May, the special statements that initially discussed the considerable to high danger from strong winds, low freezing levels and heavy rain or snow early in the week gradually shifted to discussion of substantial instabilities and large loose, wet loose or wet slab avalanches due to high freezing levels and strong sunshine. Cooler but generally dry weather allowed this danger to gradually decrease by the 8th of May, and the seasonal spring statement was issued for the first time of the year on that date. Also this briefly better weather allowed WSDOT highway maintenance and avalanche crews to conclude plowing and control for the springtime reopening of Chinook Pass/Highway 410. Although WSDOT had hoped to open the pass the previous week, the substantial new snowfall and associated avalanche danger in the clearing and warming following the new snow prevented such an event, with the initial opening delayed until May 10th. (However, even after the opening, periodic closures were required for additional avalanche control or snow stability assessment through the 21st of May—see below).

Figure 6. Freezing levels and Precipitation—May 2001



Spring once again turned to winter on Monday May 14th through early Wednesday May 16th when a series of very strong frontal systems moved across the area supported by a 140-165 knot jet stream (where were these deep troughs during the winter?). These fronts deposited from 1 to 3+ inches of water over most Cascade and Olympic west slope areas and near the volcanic peaks. While much of the precipitation was rain at mid and low elevations between 1 to 3 feet of new snow accumulated above about 4-5000 feet in the north and above 6-7000 feet on Mt Hood. On the 16th of May, explosive control by the Washington State Department of Transportation avalanche crew on avalanche paths affecting Highway 410 near Chinook Pass produced slab releases of 18 inches running on the old crusted surface (around the 6000-6500 ft level). Reports from the Timberline ski patrol on Mt Hood indicated about 2 feet of recent snow at the 8000-foot elevation, producing a potential danger to climbers both from current wind slabs and from wet loose slides when warmer weather returned.

As a result of this new snowfall, special avalanche statements were once again issued on the 14th and 16th with further updates on the 17th and 18th (Friday) to describe the destabilizing effects of the expected warm up late in the weekend. Fortunately no accidents occurred over the weekend and after a final update on the 21st of May (the warmup was ongoing with freezing levels still rising), the normal spring statement was reissued on the 22nd. Although a moderate front moved over the region late in the Memorial Day weekend (late Sunday, the 27th through early Monday the 28th), only minor new snow accumulations were observed below about 7000 feet (Paradise on Mt Rainier at 5500 ft reported 3 to 4 inches, and White Pass at 6000 feet about 4 inches) and this produced only a slight increase in the danger at these elevations. Unfortunately, the new snowfall combined with very strong winds above 8-10,000 feet produced some new loose snow and wind slab over an old crust, and a party of four climbers on Mt Rainier were involved in an avalanche at the 13,500 ft level on Liberty Ridge. While details remain sketchy as of the date of this writing, the avalanche apparently overran the group and removed a significant amount of climbing equipment, essentially trapping the party and

necessitating rescue by the Park Service (a radio call for help was apparently picked up by a local ham radio operator and relayed to Mt Rainier National Park). At least any injuries appeared to be minor and all of climbers were able to climb back up the summit with the rescue team to await subsequent airlift out via helicopter.

CLIMATE SUMMARY

As indicated in the weather and snowpack summary above an extended period of dry weather persisted through much of November and early December dropping the snowpack to 1/3 to 2/3 of normal by early-mid December. Things picked up a bit by the 15th of December but only slightly:

DATA BELOW IS IN INCHES, -99 DENOTES MISSING DATA

For 15 December, 2000

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 1999 MAX/YEAR	THRU 1999 MIN/YEAR
MT BAKER	41	68	60	108	168/1948	16/1976
STEVENS	38	44	86	68	80/1973	5/1976
SNOQUALMIE	35	36	97	63	116/1948	0/1976
STAMPEDE	32	44	73	57	119/1948	9/1976
PARADISE	41	69	59	109	170/1948	4/1976
WHITE PASS	21	31	68	40	73/1996	2/1989
MT HOOD	47	58	81	61	118/1984	8/1989

Depths dropped again by the 1st of the New Year as only light amounts of new snow or (dare we say it) rain or freezing rain graced many areas in the Northwest mountains:

1 January, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	48	89	54	96	190/1949	1/1928
STEVENS	41	63	65	67	117/1956	10/1981
SNOQUALMIE	46	53	87	51	136/1949	0/1981
STAMPEDE	-99	59	-99	-99	132/1949	0/1981
PARADISE	54	91	59	94	163/1969	20/1977
WHITE PASS	26	35	74	26	84/1997	4/1990
MT HOOD	54	69	78	58	145/1985	6/1981

Despite the lack of significant storm systems described in the weather summary above and the generally below or much below normal climatological snowdepths in the summary tables, it was obvious from the number of accidents that the avalanche danger was far from insignificant. Hopefully the continued daily (or more often as needed) availability of avalanche and weather forecast information issued by the Avalanche Center prevented further accidents from occurring. Certainly the prevalence of splits and blocks and a related lack of sustained strong

westerly flow for most of January-March helped keep the snow depths generally low as shown below:

15 January, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	50	110	45	162	180/1971	15/1981
STEVENS	41	74	55	118	146/1969	6/1981
SNOQUALMIE	44	66	67	89	179/1972	0/1981
STAMPEDE	38	74	51	-99	132/1949	0/1981
PARADISE	69	113	61	159	216/1969	31/1981
WHITE PASS	37	46	80	80	80/2000	0/1981
MT HOOD	61	87	70	136	144/1989	0/1981

1 February, 2001

MT BAKER	77	125	62	155	234/1933	17/1981
STEVENS	55	88	62	119	152/1964	10/1981
SNOQUALMIE	59	79	75	104	154/1964	8/1977
STAMPEDE	57	88	65	104	228/1946	2/1977
PARADISE	90	133	68	156	240/1969	27/1977
WHITE PASS	40	52	77	73	88/1997	0/1977
MT HOOD	66	98	67	133	156/1982	15/1981

15 February, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	93	141	66	157	244/1999	24/1977
STEVENS	67	96	70	118	166/1956	16/1977
SNOQUALMIE	66	88	75	99	168/1949	4/1977
STAMPEDE	62	93	67	95	202/1949	0/1977
PARADISE	96	145	66	162	264/1972	24/1977
WHITE PASS	41	56	73	78	100/1999	0/1977
MT HOOD	65	109	60	145	162/1999	27/1981

1 March, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	87	152	57	169	296/1999	48/1981
STEVENS	63	101	62	115	196/1956	30/1981
SNOQUALMIE	66	91	73	99	198/1956	20/1981
STAMPEDE	60	101	59	100	195/1969	21/1981
PARADISE	98	159	62	183	276/1999	67/1977
WHITE PASS	39	58	67	79	115/1999	11/1977
MT HOOD	67	117	57	149	199/1999	38/1981

15 March, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	90	166	54	185	305/1999	44/1981
STEVENS	64	105	61	113	200/1956	26/1981
SNOQUALMIE	60	93	65	98	195/1956	10/1957
STAMPEDE	60	105	57	-99	216/1964	13/1981
PARADISE	102	171	60	187	357/1956	72/1981
WHITE PASS	32	57	56	77	132/1997	8/1981
MT HOOD	71	120	59	144	188/1999	33/1981

1 April, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	99	176	56	193	311/1999	72/1934
STEVENS	65	102	64	112	192/1956	24/1941
SNOQUALMIE	54	87	62	92	170/1956	2/1992
STAMPEDE	59	102	58	101	183/1956	17/1992
PARADISE	116	176	66	187	327/1956	66/1941
WHITE PASS	24	54	44	70	110/1997	0/1992
MT HOOD	68	124	55	140	199/1999	55/1992

Fortunately the late season incursion of snowfall in April brought a partial restoration of the mostly well below normal snowdepths reported during most of the rest of the year. As the mid-April depths indicate, almost 70% of normal seemed pretty good when most of the rest of the year was hovering between 40-60%.

15 April, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	109	169	64	176	290/1999	56/1934
STEVENS	68	95	72	102	170/1956	17/1941
SNOQUALMIE	58	73	79	68	153/1974	0/1992
STAMPEDE	-99	100	-99	-99	216/1964	9/1992
PARADISE	127	173	73	171	302/1972	68/1934
WHITE PASS	24	46	52	58	95/1997	0/1992
MT HOOD	82	123	67	121	190/1982	54/1992

The series of strong late April storms mentioned in the weather and snowpack summary above produced a significant increase in the climatological snowdepth percentages for higher elevation stations like Mt Rainier and Mt Baker. However, since the 30-40 inches of new snow had little time to settle before being included in the May 1st summary, the large percentage increase noted was inflated and percentages in the 70-80% range are probably more representative (30-40 inches of new 10% (100kg/m3) snow settling to about 10-13 inches 30% snow (300kg/m3) within a week or two of warmer spring weather).

1 May, 2001

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2000 MAX/YEAR	THRU 2000 MIN/YEAR
MT BAKER	126	138	91	168	270/1999	20/1934
STEVENS	62	83	75	81	141/1964	36/1942
SNOQUALMIE	35	62	56	50	131/1974	0/1992
STAMPEDE	-99	82	-99	67	176/1964	1/1992
PARADISE	140	161	87	155	295/1972	36/1941
WHITE PASS	8	25	32	36	70/1999	0/1996
MT HOOD	71	118	60	105	162/1997	70/1994

The following graphs (Figures 7-10) visually depict the evolution of the winter season snowdepths and precipitation. While the Pacific Northwest flirted with near normal snowdepths through mid December, the very dry period from mid December through the end of January became too great a deficit to overcome. However, a stormy spring with unseasonably low freezing levels helped significantly offset the otherwise rather dismal season. Although this late season rebound is not evident in the lower elevation (3000 ft / 915 m) Snoqualmie Pass data below, and only partly evident in the Stevens Pass data (4080 ft / 1244 m), it becomes much more obvious in the Paradise (5500 ft / 1671 m) and more northern Mt Baker data

Figure 7. Snoqualmie Pass snow depth versus climatology

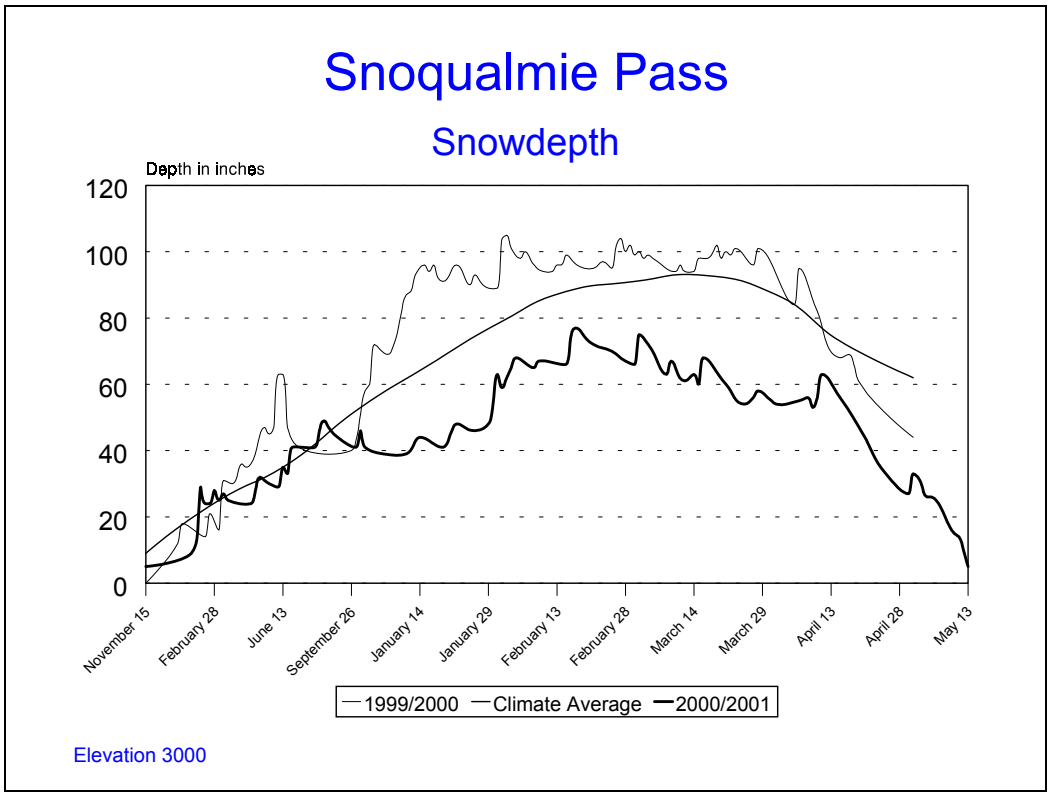


Figure 8. Stevens Pass snow depth versus climatology

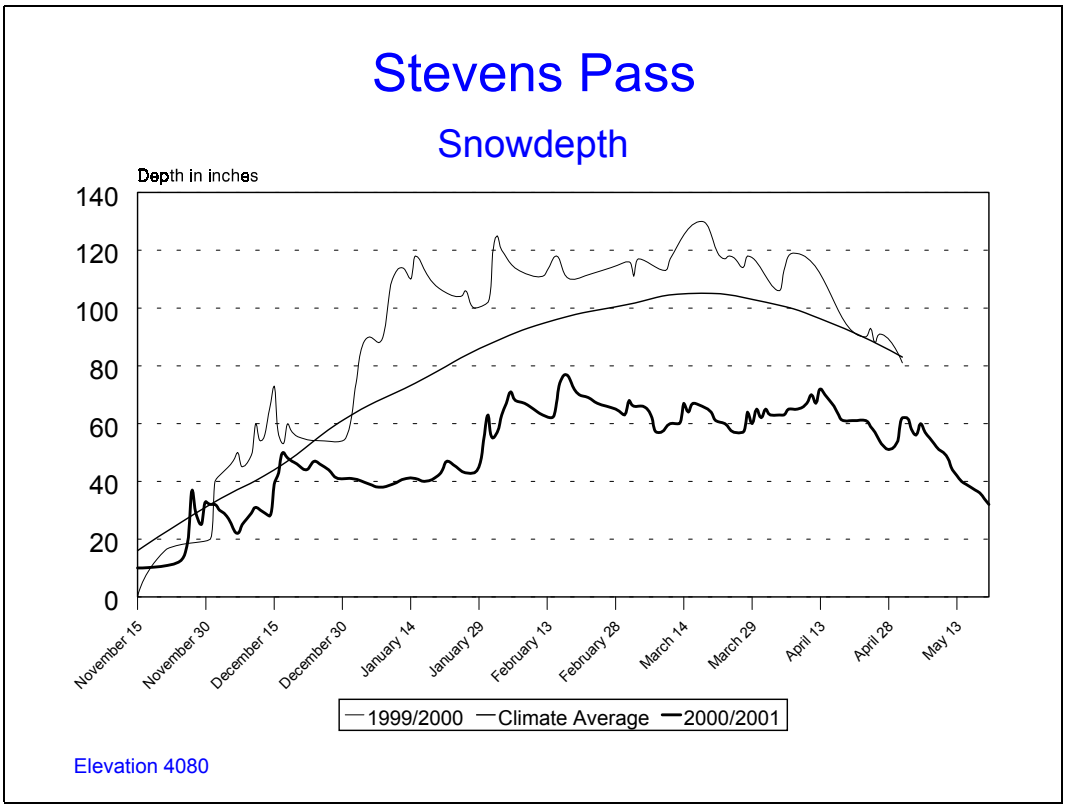


Figure 9. Paradise snow depth versus climatology

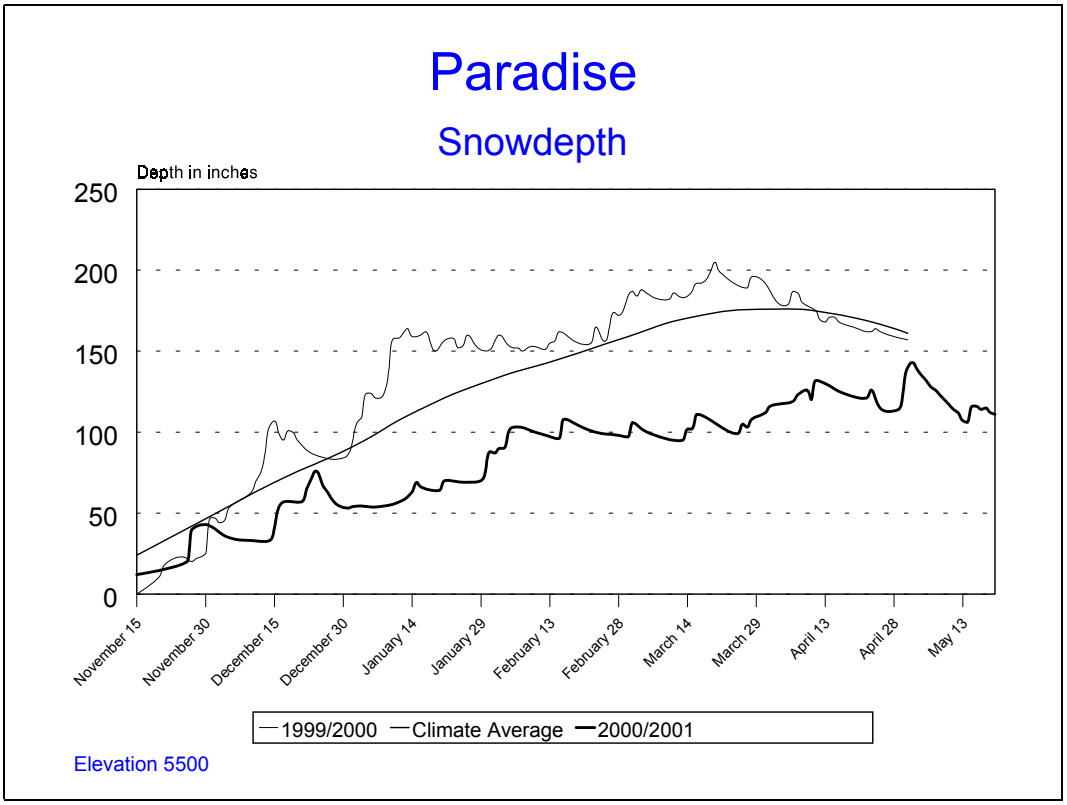
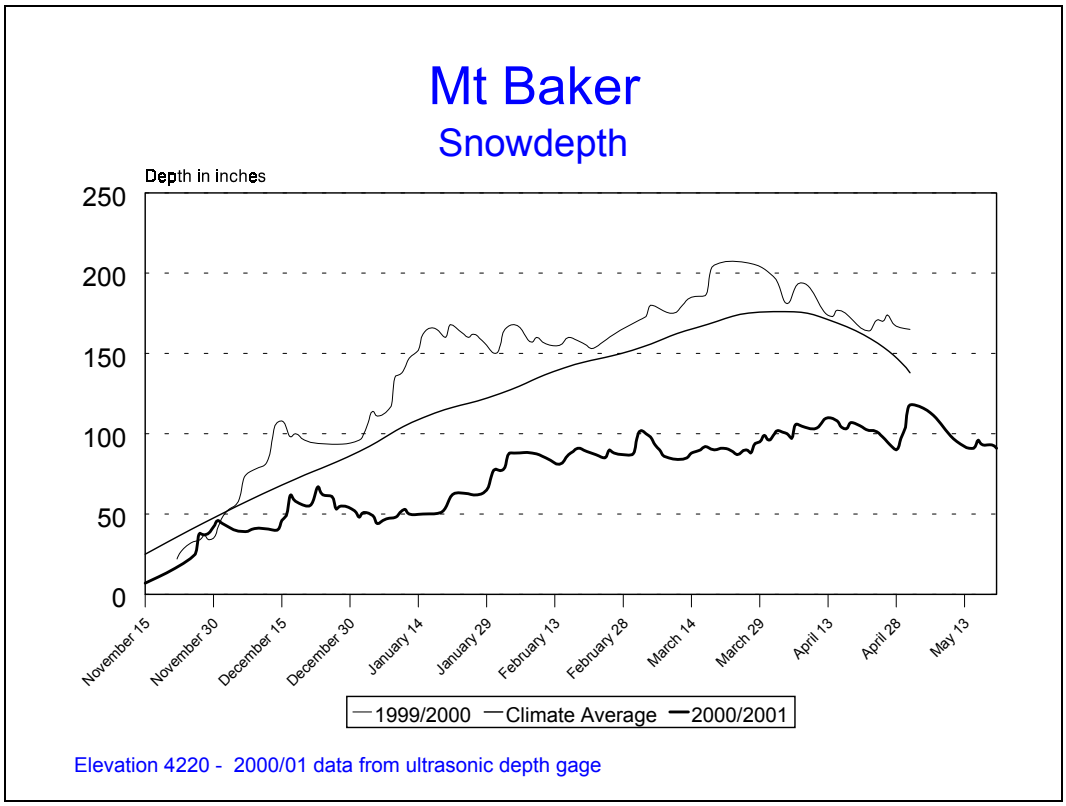


Figure 10. Mt Baker snow depth versus climatology



As is evident from the monthly and annual precipitation figures below, monthly precipitation was well below normal for the period November-January. And overall the annual precipitation ranked as the second driest winter since 1973—at least for this Stevens Pass site.

Figure 11. Stevens Pass Monthly Water Equivalent--2000/01

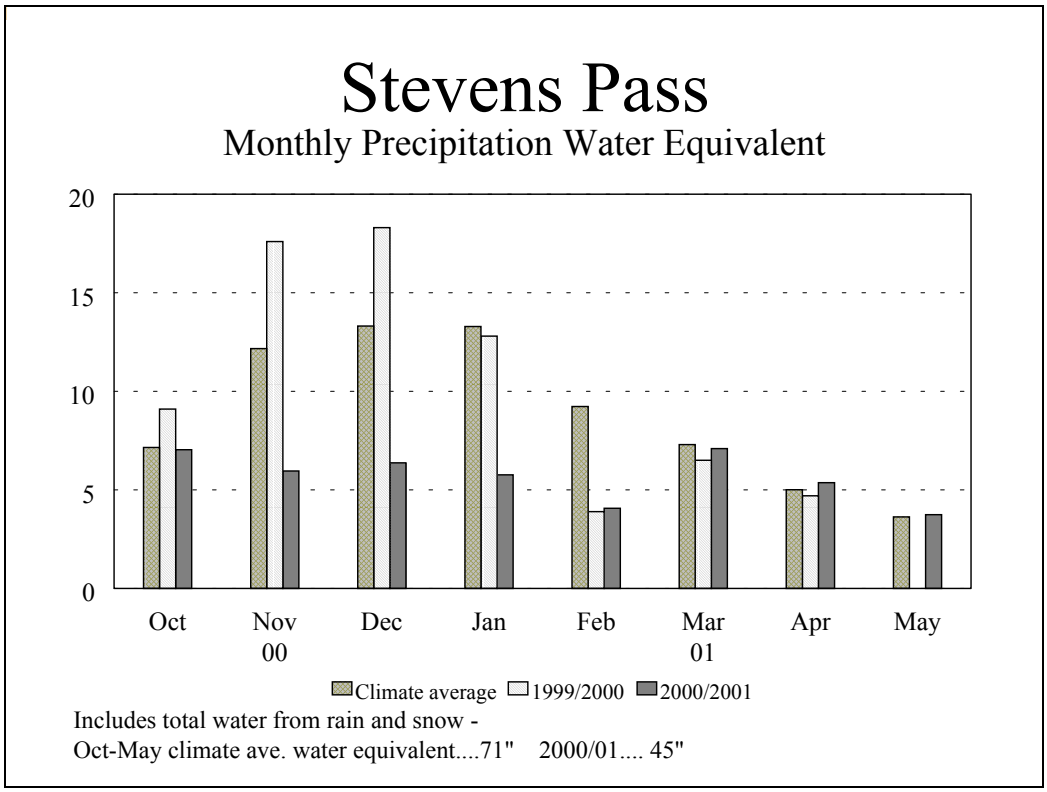
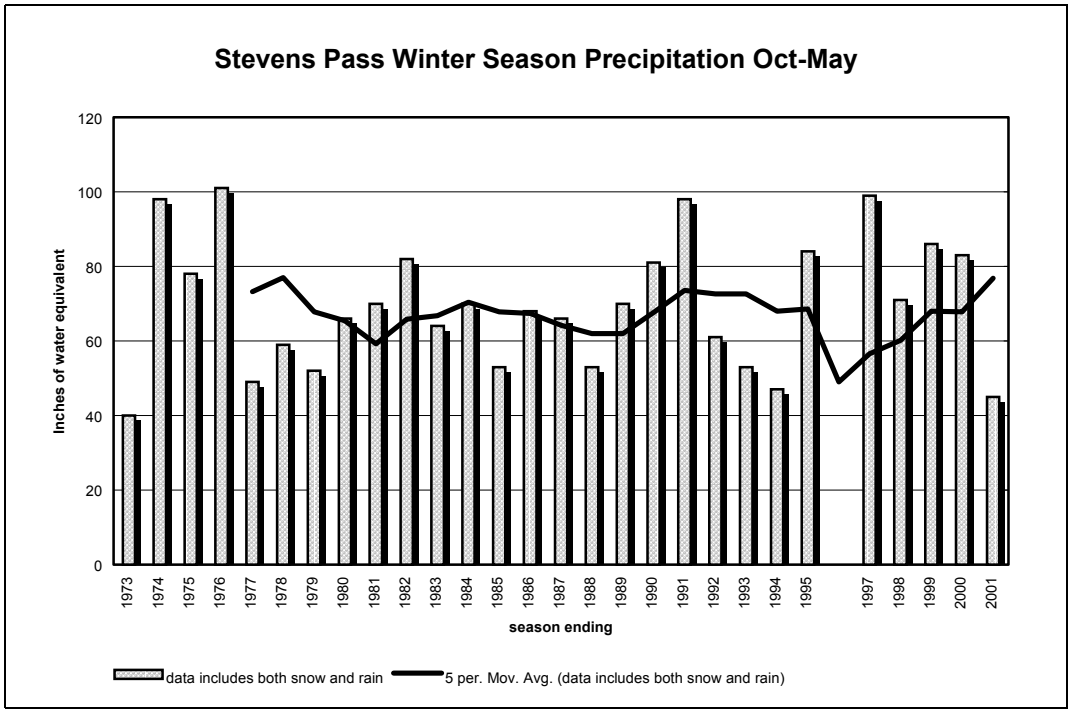


Figure 12. Stevens Pass Seasonal Precipitation--October thru May



AVALANCHE ACCIDENTS

The following two summaries about human avalanche involvements typified the early part of the winter season—a shallow weak snowpack that could have been much more deadly in the Northwest:

Discussion of the Back Country conditions near Crystal Mountain on Saturday, 12/2/00—received as an email at the Avalanche Center…

> *"Lance was up in the backcountry at crystal on Saturday (it was closed, so it hadn't been blasted or anything). He and his friend Dave Strohm set off a climax avalanche with a foot and a half crown, that took out half the basin (all the snow on the north half of silver basin slid) The snow slid all the way to the ground. They were both in it but made out OK - no injuries - just a bit of lost gear. They were just in the process of digging a pit when it went off. Because they were 6 feet from the crown I think they fared better than if they had been further down the slope. They had already taken two runs down this thing and were just starting to feel some funny settling. When they dug the pit they found that there was 4 to 6 inches of NOTHING between the snow and the ground. They were on the north facing aspect of silver basin between 3 way peak and gun tower. There was NO BONDING between the ground and the snow pack on the whole north exposure.*
>
> *Yikes!! Be careful out there*."

Discussion of an avalanche involvement near Blue Peak near Washington Pass on 12/28/00—also received as an email to NWAC:

> "*Thought you might like to know .12/28/00*
> *Party of four skied the S,S.E bowl off of the 7600' col of Blue Peak (WA Pass).We have been skiing this area recently (we live in the Methow Valley and have been skiing this area for years) and from our own and others observations have felt that south slopes have gradually become relatively stable.We skied the run to about the 6400',6600' level where the rain crust became more pronounced,then climbed back up to the col.While three of us were sitting in the lowest point of the col the fourth the climbed slightly higher and to the west (probably 40 yards away)where he dug a pit to the ground,once he reached the ground the slope fractured above him (aprox 30') and below and around him quickly propagating across the the slope and running to the ground aprox 600'800' vertical feet (I would guess abought 400'600'wide)it then ran on top of the snow aprox anoyher 600'800' and disappeared from view and I presume it may have run to the valley floor.Noburials or injuries.Between the four of us we probably have close to 80 years of backcountry skiing experience,personally I have been skiing out of the Methow Valley for over 20 years and have never seen it so sketchy. Anyway thanks for the effort you put into the NWAC.-- Matt Firth*"

One of the snowpack properties that may have helped in limiting the number of accidents was that the snowpack was so weak and shallow along the Cascade east slopes that snowmachines were unable to get very far into steeper terrain before breaking through to the ground and being unable to move much further.

In mid-late January, the first significant snowfall in quite some time brought bad news. . . as the first Northwest avalanche fatality of the season occurred in the Twin Lakes area just north of

lake Wenatchee on Monday January 29th. Following heavy snowfall, a pass wind shift at nearby Stevens Pass and resultant warming (a rise of about 10-15 degrees in the hour and a half around the time of the accident), a party of two people on snowshoes traveling on a summer trail triggered a small slide above them. Though only about 40 feet long by 6 to 8 feet wide initially, the small slide spread out as it descended and caught both in the party, partially burying one and totally burying the other and a dog in a creek bed at the bottom of the small path. The woman in the party was buried to her waist and was able to self-rescue after about 30 minutes. However, She was not able to locate her companion and they had no rescue or transceiver equipment with them. It was not until two days later--Wednesday morning, the 31st, that rescuers recovered the victim. The slide appeared to release from a small wind roll in a clearing adjacent to a treed slope, with details and pictures of the accident available on the NWAC web site.

The day after this incident, a ski patroller at Alpental triggered an 18-inch soft slab adjacent to the regularly controlled area on Tuesday January 30th. The slope was quite small (about 50 ft vertical) but ended on a shallow bench that allowed for relatively deep burial. As a result the victim was buried about 4 feet deep. Since all members of the control group had beacons, probes and shovels, and had practiced rescue techniques, the event had a fortunate outcome as the patroller was found and rescued by his partners in 6 minutes. Although he was already turning blue and beginning to pass out, he recovered quickly and apparently finished the workday! Kudos to all who contributed to this positive ending.

And yet another patroller triggered and was caught in a 3 ft slab on the backside of Crystal Mountain on the 4th of February. Fortunately this too had a positive result, as the patroller was only partially buried and sustained relatively minor injuries (tweaked knee and bruised thigh).

On February 17th two more avalanche accidents occurred in the Washington Cascades, with one a fatality. Ostensibly enroute to a nearby ridge, a snowmobiler triggered and was caught by a 2 foot slab that carried him through trees where he apparently suffered fatal trauma injuries. The snowmobiler and his machine were apparently swept into relatively heavy timber and subsequently buried, resulting in a broken neck and a significantly damaged machine. Other snowmobilers were in the area and apparently uncovered the victim relatively quickly by probes and surface clues, but to no avail. This accident occurred near Van Epps Pass, east-northeast of Snoqualmie Pass and west of Mt Stewart in the central Washington Cascades.

Then on the same day (the 17th) at Crystal Mountain a local skier ducked a closed area rope and proceeded to trigger about a 4-foot fracture. He was swept downhill some 500 vertical feet and received considerable head trauma (including a broken jaw) and a broken arm for his effort.

While avalanche accidents in the Northwest took a break in March when rainfall and snowfall were much lower than normal, the national avalanche fatality count continued to rise in March and April, setting a new modern day record of 33 avalanche deaths with two hiking fatalities in Utah late in April. In the Northwest a very cool and snowy April (as described in the weather and avalanche section above) produced several more Northwest avalanche accidents that are summarized below.

Mt Baker – 1 April

The new snow that arrived in late March lured more skiers out into the back country in early April with a close call reported off Blueberry Ridge (on the way to Table Mountain from Mt Baker ski area base) on the first of April (April Fools??). In this incident, an experienced and well equipped skier (beacon, probe, shovel), who had recently taken several avalanche awareness classes from the snow safety director for the ski area, ventured unroped onto a recently formed cornice. His weight apparently caused the cornice to break off and he and the cornice freefell onto the steep slope below, entraining the 6-10 inches of new snow and descending through a small stand of trees to the valley floor some 600 vertical feet below. The cornice collapse and the ensuing avalanche were witnessed by both a companion and another touring party, who quickly skied to the toe of the slide, located and uncovered the victim via beacon search, probing and shovel within 10-15 minutes of the event. While cold when found, the victim was apparently still breathing (possibly because of larger cornice blocks creating air pockets). Meanwhile the ski area had mounted a rescue effort and arrived at the scene with patrollers and snowcats. The victim was subsequently taken to the first aid room, checked for injuries and released with no apparent injury. While he was undoubtedly a very lucky skier, he was charged for the cost of the rescue into the wilderness area by the ski area. But most folks would consider $500 relatively cheap insurance when your life is at stake.

Mt Baker – 11 April

The following is a report using information from Brandon Weathermon, patrol director for the Mt Baker Ski area and who was a member of the Search and Rescue party.

The snowmobiler victim was high marking a south-facing slope at about 6600 feet between 9 and 10 am. While highmarking, he triggered a 2 to 2.5 foot slab that was estimated to be about 1/3 mile wide and ran about 700 vertical feet. This slope may have been loaded by strong northeast winds, seen at several weather stations, earlier that morning or the night before. At least 3 other snowmobilers witnessed the avalanche. Other snowmobilers were also in the area, some of whom had beacons and probes. Apparently the victim's snowmobile and helmet were found relatively soon in the debris, but unfortunately the victim was not wearing a beacon. As a result his rescue was initially relegated to disorganized probing efforts by the nearby snowmobilers.

Search and Rescue personnel arrived between 1 and 2 pm. The debris was blocky, hard wind slab debris. By this time about 30 snowmobilers had gathered, about half of whom had probes, beacons or shovels, however an organized probe search had apparently not been performed. A probe line was subsequently organized and the victim was found about 530 pm, buried about 3-4 feet below the surface, at about the 6200 ft level. The body was found directly below the last seen point, about 150' up the hill from the victim's snowmobile.

Washington Pass – 14 April

(From a report received at the Avalanche Center via the Internet—)

Thursday, three of us (members of the Seattle Mountaineers), skinned up and then kick stepped up to Blue Peak Col. From there we skied the slopes west to the right from the Col down and through the trees until it flattens out. The slope appeared very solid with about a foot of new powder. Since the short run from the Col was not that great, we repeated the run(s) from the flatter angled area next to the Spires. The same we did Friday, still in good powder. Saturday eight of us decided to ski the "Birthday Tour". Arriving at the top of the Col we decided to ski in pairs and conservatively light and easy towards the bottom of that valley. The surface appeared to be breakable crust! We re-grouped 2/3 on the way down, where the slope seems to terrace a little bit - next to a fairly good sized slab release, covered however with new snow (150 meters in length minimum). Since the sun was warming things up the group hesitated/evaluated a little until two or three started to ski on. There was a short steeper section between small trees just

ahead of us. After one of us skied it safely until the next (light) treed area I took my turn. I found myself sliding out and quickly realized this is a slab breaking loose. The crown was maybe 8 meters above me and the width about 25 - 30 meters maximum. First it seemed to gain momentum, I tried to poke my poles through the little blocks in hope to slow and let the avalanche proceed without me. (The depth was about a foot). That did not work. My head was uphill which I intended to keep. My left foot felt being pulled, covered with more snow. So I tried hard to drag it to the surface. About then, the movement stopped. More frantic pulling on the legs until it was possible to move out of the slide. The length of the ride was probably 40 - 60 meters. I'm not sure, but the impact could have been greater had I been further down in the slide. Perhaps it could have trapped me a little more. The length of the slab including run-out, was say 80- 100 meters. If you go there, I'm positive it'st still very visible. The breakable crust, to post-evaluate, probably made us think the slope is more stable. Besides having pulled my muscles to much, nothing else happened. After this a few of us remained quite upset for a while. We did exit through the tiny col south-east, where we skied out to the hairpin in pretty good powder.

Mt Rainier – 28 May

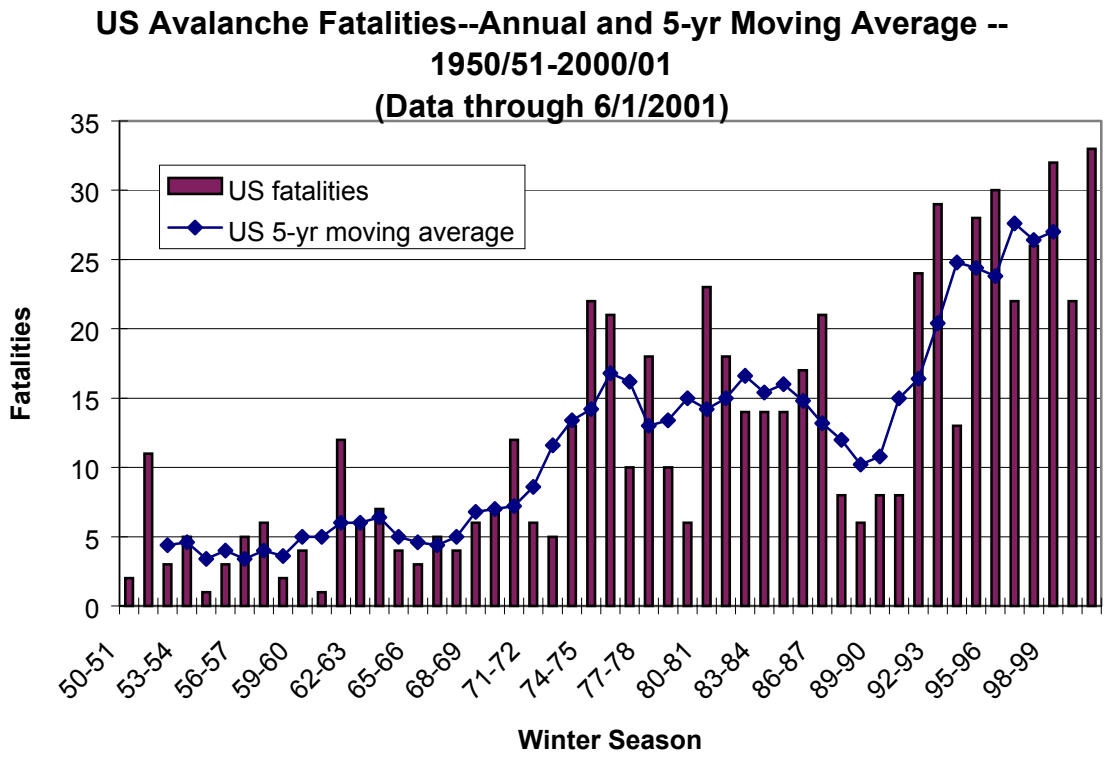
Following a quick late season snowfall late on the 27th of May and early on the 28th, another late season accident occurred on Mt Rainier at the 13,500 ft level on Memorial Day morning, the 28th, when a partly of four climbers were overrun by an avalanche. The storm was accompanied by very strong winds and at least some moderate snowfall at higher elevations, which produced either unstable loose snow or a wind slab over an old crusted snow surface. Fortunately apparently only minor injuries and some lost equipment resulted.

Although a near to below normal snowfall and snowdepth season was experienced in most areas nationally, the season was by no means below normal in terms of avalanche fatalities. Once again for the second time in three years a new fatality record emerged for the United States, with 33 fatalities as of the date of this writing. Apparently many problems were associated with the prolonged weak snowpack structure that was prevalent in much of the western US during the past winter—especially in areas where such a structure is not commonplace. And then when any new snow arrives it appears to lure snow seekers out in droves, some with little or no knowledge of the current snowpack stability or structure. The charts below show how this season compares with the recent past, both in terms of overall fatalities as well as state by state.

Table 1. US Avalanche Fatalities by State, 1985-2001

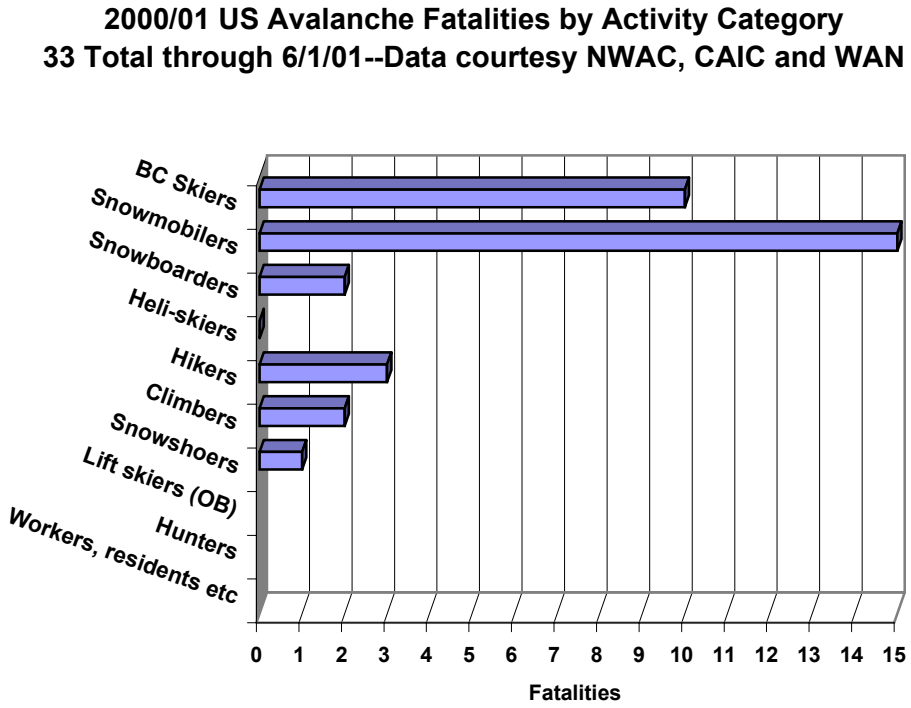
UNITED STATES AVALANCHE FATALITIES by STATE 1985-1986 to 2000/2001 (To June 1, 2001)																			
	Winter Season Ending																16 Years		
STATE	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**Total**	**Average**	**STATE**
CO	4	11	5	4	4	6	9	12	1	9	7	1	6	6	8	4	97	6.1	CO
AK	0	6	2	0	1	1	2	7	2	6	8	4	3	12	5	4	63	3.9	AK
UT	5	2	0	0	1	0	5	3	1	5	2	6	2	5	2	6	45	2.8	UT
MT	2	1	0	0	1	0	1	1	6	3	3	1	7	2	2	7	37	2.3	MT
WY	2	0	0	0	0	0	2	1	1	1	3	2	1	2	0	7	22	1.4	WY
WA	2	0	1	0	0	0	2	0	0	1	0	5	2	3	1	3	20	1.3	WA
ID	0	1	0	0	0	0	0	2	0	0	3	3	3	0	2	0	14	0.9	ID
CA	2	0	0	0	1	0	2	1	0	2	0	0	1	1	0	2	12	0.8	CA
OR	0	0	0	1	0	0	0	1	2	0	0	0	1	1	0	0	6	0.4	OR
NH	0	0	0	0	0	1	0	0	0	0	3	0	0	0	1	0	5	0.3	NH
NV	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	0.1	NV
NY	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	2	0.1	NY
AZ	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.1	AZ
NM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.1	NM
TOTAL	**17**	**21**	**8**	**6**	**8**	**8**	**24**	**29**	**13**	**28**	**30**	**22**	**26**	**32**	**22**	**33**	**327**	**20.4**	**TOTAL**

Figure 13. US Annual Avalanche Fatalities—1950-2001



During much of the recent past, at least part of the expanding avalanche fatality toll involves snowmobilers (see Figure 14 and Table 2 below), and most of these snowmobiler related accidents involve high-marking. This snowmobiler activity has become increasingly deadly of late as newer and better machines and the strongly promoted lure of highmarking, cornice jumping and other adrenaline pumping experiences have propelled sometimes uninformed riders into steeper and more dangerous avalanche territory. The combination of more weight (rider and machine can easily weigh 6-800 pounds or more—with machines alone tipping the scales at 5–600 pounds), greater power, and increased rider skills often sends man and machine (very few women seem to be involved in snowmobile or any other avalanche accidents) directly into the avalanche starting zone and subsequent avalanche incidents. As with a skier or snowboarder, this at times prolonged exposure to unstable snow in a steeper starting zone can produce shear failure and subsequent fracture of a weak layer, especially when the combined weight of sled and rider is considered along with machine vibration, the track/cut of the sled, and the rider attempting to jerk his machine from a possibly stuck and vulnerable position. With snowmobilers comprising nearly half of recent avalanche fatalities to date, and a relatively large percentage of all avalanche related accidents in the last few years, it seems like a good time for the participants of the sport to reassess the wisdom of the *highmark*, or at least to approach it with increased knowledge of the underlying snowpack structure and stability.

Figure 14. US Avalanche Fatalities by Category, 2000/01



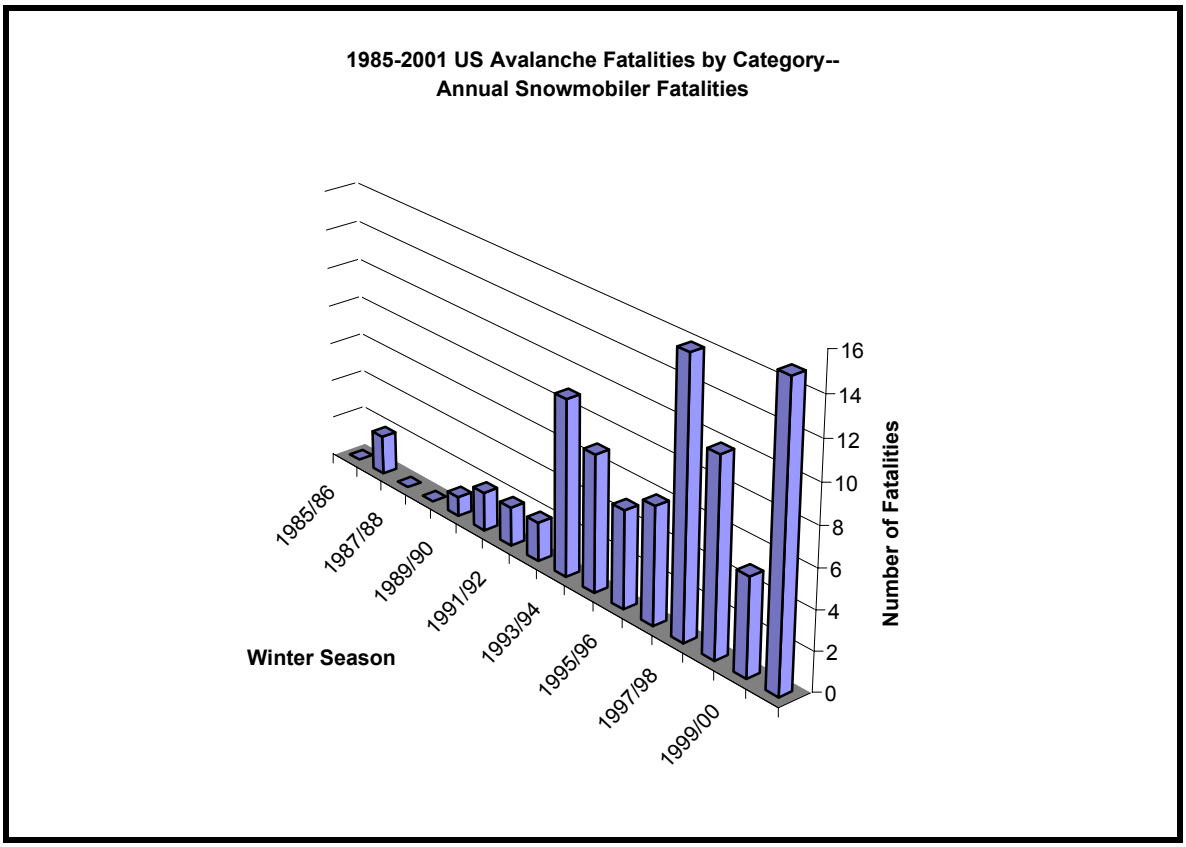
Looking at Figure 15 and the Table below, it is evident that snowmobilers account for a relatively large percentage of fatalites nationwide—45% this year and almost 40% during the past 4 years. Together back country skiers and snowboarders account for another almost 40% with hikers, climbers, snowshoers, hunters, residents, workers and others rounding out the remaining 20%.

Table 2. US Avalanche Fatalities by Category--1997-2001

US Avalanche Fatalities by Activity Category						
Activity Category	1997/98	1998/99	1999/00	2000/01	Total	Percent of Total
BC Skiers	2	3	9	10	24	21.24%
Snowmobilers	14	10	5	15	44	38.94%
Snowboarders	4	12	1	2	19	16.81%
Heli-skiers	0	0	0	0	0	0.00%
Hikers	2	1	0	3	6	5.31%
Climbers	2	1	0	2	5	4.42%
Snowshoers	1	1	1	1	4	3.54%
Lift skiers (OB)	1	1	4		6	5.31%
Hunters		1	0		1	0.88%
Workers, residents etc		2	2		4	3.54%
Total	26	32	22	33	113	

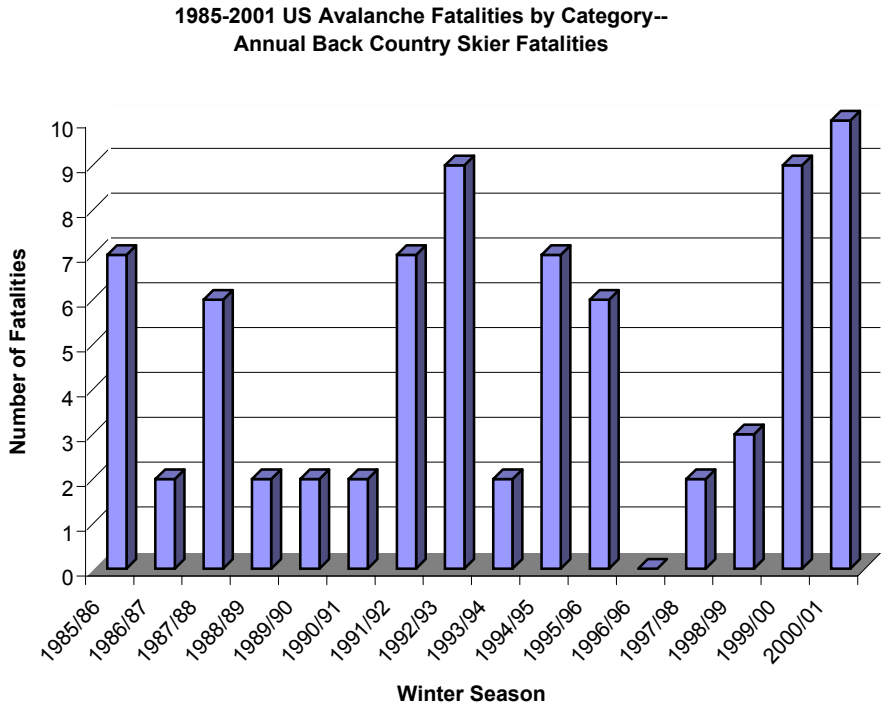
Many different conclusions can be drawn from charts showing avalanche fatalities by category, and some may or may not be valid. However, they do show trends in incidents involving particular participant groups. For instance, statistics for the winter of 1999-2000 showed a significant drop in snowmobiler and snowboarder related fatalities and a dramatic rise in back country skier fatalities. From this it was thought that perhaps the disastrous numbers of fatalities from 1997-99 for snowmobilers and snowboarders had made a positive impact on sledders and shredders (more caution and better informed decisions?) and that back country skiers had become less informed, more complacent or maybe more extreme. However, analysis of the accidents and the current year's data for BC skiers (Figure 16) and snowmobilers (Figure 15) indicates that poor decisions continue to be made even with increased education efforts and an increasingly large amount of forecast and mountain weather data available.

Figure 15. Annual US avalanche fatalities—Snowmobilers, 1985-2001



It must be noted that even a really fast and powerful machine will help very little in avoiding a slide after the rider is thrown off the snowmobile and into a tumbling mass of snow. Although the extreme parts of any sport may lead to a high degree of danger, better education and informed decision making can reduce the risk—and this is certainly true in avalanche danger mitigation.

Figure 16. Annual avalanche fatalities—BC skiers, 1985-2001



If viewing the following charts were conclusive evidence of trends in safety and avalanche awareness, it could be hoped that both snowboarders and climbers have learned much of late and are now using greater caution and care in route selection, trip planning, stability analysis and evaluation. Only time will tell for sure…

Figure 17. Annual US Avalanche Fatalities—Snowboarders, 1985-2001

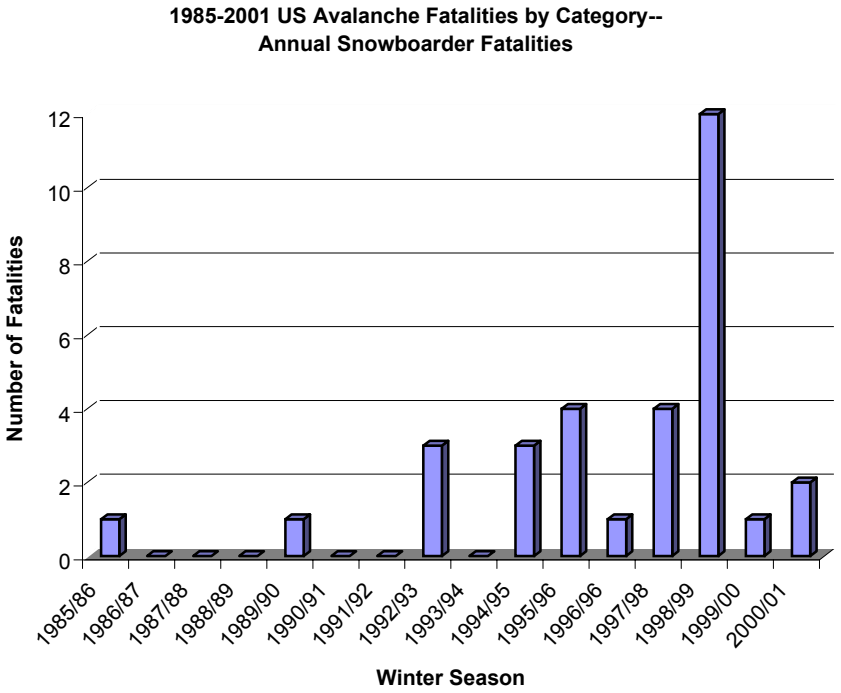
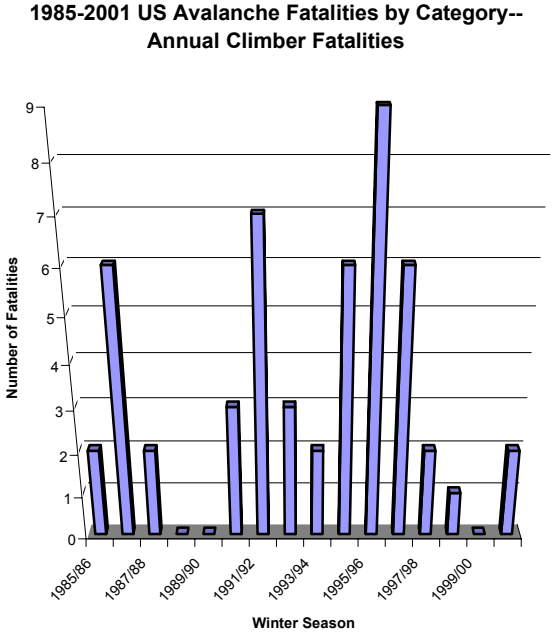
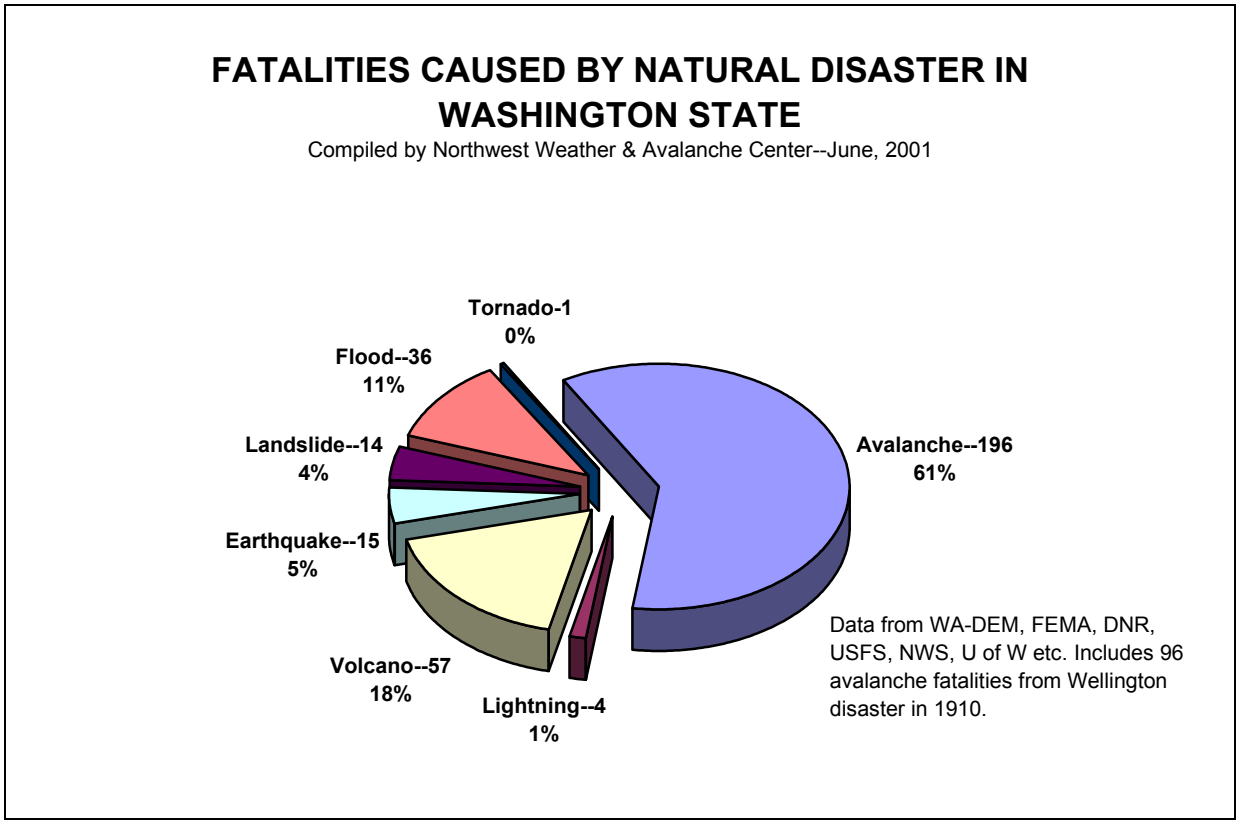


Figure 18. Annual US Avalanche Fatalities--Climbers, 1985-2001



Whatever the nationwide statistics for declining or increasing avalanche fatality categories show, and whatever the statistics for annual averages or trends indicate, the avalanche threat continues to be a real and very valid phenomenon worthy of everyone's concern and awareness. As is obvious in the following chart (which includes the 96 fatalities killed in one massive slide event in 1910), avalanches continue to be the greatest killer of all natural disaster related incidents in the Northwest. Yet even without this incident—the largest single avalanche disaster in North America, avalanches still retain the number one position of all disaster related fatalities in Washington and Oregon.

Figure 19. Fatalities Resulting from Natural Disasters in WA



FIELD OPERATIONS

Snowpack Analysis

Current snowpack information is critical to any avalanche forecasting program, and despite the lean snow year and lack of at times significant storm activity this year was no exception. During most of the year, forecasters tried to be out in the field and analyze the snowpack at a variety of locations at least once or twice/week. Site visits entailed digging snowpits and performing snow stability tests on several representative aspects and elevations, as well as

collecting and analyzing information from local sources. Normally these field snowpack trips were done in conjunction with a necessary repair to some component of the weather data network, and forecasters tried to hook up with field personnel from the highway avalanche crews, professional ski patrollers, park rangers or other interested personnel wherever and whenever possible. On-site inspections were then combined with the normal daily stream of information on snowpack structure and stability given to NWAC forecasters by WSDOT avalanche control teams, ski patrollers and park rangers, along with intermittent observations from other reliable back country travelers. These snowpack observations normally included information on parameters such as location and strength of weak layers, snowpack evolution (faceting or rounding), water percolation, control results, ski cuts, probe tests, rutschblock and shovel shear test results, etc. Such information gave forecasters the proper basis and framework on which to base decisions on both current snowpack stability and forecasts of how expected weather might influence this snowpack structure.

Weather Data Network

General—

As usual when trying to maintain a data system that is exposed to harsh winter conditions for 6-9 months/year, the NWAC remote mountain weather data network required a significant amount of time, energy and capital equipment expenditures to keep it operational and reliable for the increasing numbers of users who rely on the information for an ever widening variety of purposes. With over $300,000 worth of weather sensors, loggers, towers and communication equipment installed in sites ranging from northern Washington to southern Oregon and from the Cascades to the Olympics, it is both a time-consuming and expensive venture to adequately maintain the system to the high standards necessary. However, the resultant quality of meso-scale data and datasets make it a very worthwhile investment, not only for operational weather and avalanche forecasting, but for planning, maintenance, visitor safety and other applications.

With an increasing pressure on NWAC to keep the weather sites up and operational not only as long as possible but on a year round basis, forecast staff are increasingly challenged to balance data quality with quantity—especially when forecasters are only hired by the Avalanche Center for 9-10 months/year. This balancing act is especially difficult in the spring when lightning storms can wreak havoc with weather sites in a matter of seconds. And it gets worse in the summer when forecaster can look at the data, recognize a problem, but be unable to fix it because of a lack of funding. With estimates of an average 8-10 year lifespan for most weather equipment (other weather agencies and vendors indicate that these lifespan estimates are reasonable for most weather equipment), keeping the data network working properly requires replacement of ~10-12% of the equipment each year or about $30-35,000 worth of capital equipment. Fortunately, such expenses have been met in the program budget by cooperating agencies and partners in the recent past—however, such recurring costs must continue to be included in future funding levels otherwise a significant degradation in the data network and related data services (and the forecasting services which they support) will result. Currently a significant funding shortfall is projected for Fiscal Year 2002 and such a shortage may significantly impact capital equipment available for the data network—if not rectified, the reliability and quality of the data network will suffer.

As in years past overall data system maintenance involved a continued program of upgrades and enhancements to provide for the most reliable and accurate weather data possible. Fortunately after a significant replacement effort the year before from damaged sites following the unusually heavy snowfall winter of 1998/99, a slightly less intensive infrastructure effort (tower replacement) was required last season during the summer and fall of 2000. However, installation of a new tower site and power/telemetry system was necessary to support the new hourly meteor-burst telemetry weather station at Mt Baker (a CR10X datalogger and associated weather sensors were installed to augment and eventually replace the old satellite based weather station—see below for details). And to provide for better future reliability of several key stations and associated weather data, installation of several new towers and multiple datalogger locations are planned for the summer and fall of 2001—at several Mt Hood stations (Timberline, Mt Hood Ski Bowl and maybe Mt Hood Meadows) and possibly Stevens Pass. Also significant changes are in order for the radio-linked Chinook Pass sites (potential replacement or repair of three radios and RF modems), the satellite based Washington Pass site, Stevens Pass (possible consolidation of the Grace Lakes system into the ski area system), Mt St Helens (enhanced guying and bracing of the precipitation and wind tower), and Hurricane Ridge (possible new precipitation/snow depth tower). In addition to these special past and future site efforts, almost all NWAC telemetry sites were visited and damaged sensors repaired or replaced early in the fall of 2000. During October and November, several trips were made to the following sites for troubleshooting and repair: White Pass, Washington Pass, Hurricane Ridge, Snoqualmie Pass, Alpental, Paradise, Crystal Mountain, Chinook Pass, Mt Hood, Mt Baker, Timberline, Mt Hood Ski Bowl, Stevens Pass and Snoqualmie Pass. The details for individual weather stations are described in the outline below.

Weather Station Highlights—

Mt St Helens—

After adding a new precipitation gage near Mt St Helens last year to augment an existing automated temperature and wind site, all of the Mt St Helens sensors and weather system seemed to work reliably with the exception of intermittently high precipitation values during high wind episodes. After examining the situation more closely, it appears that high east winds (wind averages >20-25 mph and gusts > 35-40) shake the tower and attached gage, producing a large number of anomalous tips of the tipping bucket mechanism. After discussing the situation with maintenance supervisors at the National Volcanic Monument NWAC staff are planning on a mid-late June trip to add necessary guying and stabilizing brackets to eliminate the sway/vibration problem.

Stevens Pass—

In anticipation a gradual and orderly shift from the aging Grace Lakes weather system to the newer weather system within the Ski Area, forecasters continued to help the ski area install and program several new weather sites (top of the Skyline Chair, top of Daisy and top of Tye Mill). The old Grace Lakes site, while providing on-site wind and temperature information crucial to avalanche control for the highway, continues to be increasingly difficult to maintain--as much of the infrastructure (towers and land lines) were installed in the late 1970's and are suffering more and more age-related problems. Significant problems with induced AC or DC power also continued intermittently throughout the year at the Grace Lakes installation as the surplus

Army field phone cable and used power lines show their age. Though many of the land line wires have been replaced or repaired over the past few years, the site has continued to experience intermittent temperature and other induced power problems whenever the ski lifts are turned on. A comparative sensor data analysis last year between this site and the newer ski area site shows fairly comparable results in winds, temperature and precipitation, with an even better correlation likely next year between winds and temperature at the top of a new Brooks Chair site and the Old Faithful site. This will hopefully allow removal and replacement of the old Grace Lakes weather station in the summer and fall of 2002. If so, this may save considerable time, effort and money for all parties cooperating in the Stevens Pass remote weather systems. The new weather station installed at the WSDOT Schmidt Haus observation site worked very reliably throughout the winter and provided hourly (or instantaneous on-demand) temperature, precipitation, total and 24-hr snow depth measurements to a variety of cooperators and the public.
This site was also critical for a vertical temperature and snowfall profile near Stevens Pass. The snow depth data proved particularly accurate, normally measuring within an inch or two of the nearby (within about 10 ft) manual observations.

Mt Baker—

Several trips were made to Mt Baker in the fall to install a new 30-ft (~10m) instrumentation tower (OSHA and FS approved Rohn 45G) as well as associated AC power and telemetry cables from the nearby A-frame to support a new observation site. The AC was required to heat and power sensors and dataloggers at the new site while telemetry cable was laid in anticipation of a new land line/microwave phone system scheduled for installation to the ski area base over the summer of 2001. Several meetings with FS biologists and lands and minerals personnel were required for assessing environmental impacts and for resultant permission to dig the tower base hole and trench necessary for the new site, but excellent cooperation and a quick turnaround of the necessary inspections and paperwork resulted in a workable arrangement and smooth installation (special thanks to several Mt Baker/Darrington Ranger District staff, especially Ann Risvold and Lief Hazelet). The new observation site will eventually replace the old satellite based weather site that has existed for years on the old chair tower to the north of the A-frame. While providing relatively reliable precipitation and air temperature data, the old site experienced several years of snowdepth readings well below the ski area and highway reported depths. From on-site observations, this discrepancy was deemed to be a result of accelerated wind flow around the nearby A-frame and acceleration and scouring of snow under the depth gage and across the adjacent ridge. Comparative snow depth analyses were performed between the new site, the nearby (~20 ft or 6 m distant) manual snow depth readings from the ski area, and the old weather station (about 75 yards away). This comparison indicated excellent agreement between the ski area total pole and the new automated depth gage readings while the old site's depth remained (as expected) well below these more realistic readings.

Several problems occurred with precipitation gage power and gage heaters at the new site—presumably related to power surges or some other problems in the generator supplied ski area power. In any case, after two precipitation gage replacements in December and January due to faulty rim and/or funnel heaters (more gage problems than at any other site in the system), the third gage finally began working consistently, and continued so until mid-late April when all AC power for heating both the satellite and new meteor burst station gages ceased once again.

Forecasters are planning on a hopeful long-term resolution of the problem over the summer and fall—mostly likely with a larger breaker (going from a 10 to 20 amp breaker), putting each system on its own breaker, and/or yet another swap of the gage(s).

A new meteor burst radio system, acquired through cooperation between NRCS (Natural Resources Conservation Service) and the Avalanche Center, provided more real-time hourly weather data than ever before from this station (prior to the meteor burst transmission, hourly data from the site was available only once every three hours, normally being received about 4 hours after the first hour). This transmission method required considerable tweaking of the antenna and modem on site as well as a rewrite of the datalogger program. To accommodate the meteor burst system, data from this site had to be converted into hexadecimal units at the logger before being transmitted and then reconverted
into standard engineering units before being stored on the NRCS server. NWAC programmers then provided for automatic FTP of the hourly data from the NRCS server to the Avalanche Center where it was formatted and sent out for local and web site display. Unfortunately though, the new cooperative meteorburst telemetry system did not routinely provided the truly timely information that real-time forecasting necessitates. While the data was normally available within 3 to 6 hours of the current time, lapses of more than 6-12 hours were not uncommon—such delays can severely handicap meso-scale forecasting efforts. However, despite these drawbacks the meteor burst system offers several advantages over the older satellite based system. It allows relatively direct automated access of the data from the NRCS FTP site (rather than an at times error prone automated workaround to get the data from the WIMS system). It allows forecasters to use the familiar Campbell Scientific Datalogger CR10 or CR10X rather than the more expensive and (for our purposes) less versatile Handar datalogger. In short, if the intermittent transmission problems can be mostly resolved, our usage of the meteor-burst system demonstrated that almost real-time data can be relatively reliably acquired though this transmission method.

It is possible that the Mt Baker ski area may install a microwave based phone system this summer. If this does occur and the system allows for NWAC to acquire a phone number for telemetry data, NWAC will plan to convert the new meteor burst station to a phone link site (which is normally more reliable and easier to troubleshoot than the meteorburst). This would allow the meteor burst system to be removed and reinstalled at the now satellite based Washington Pass site.

Mazama—

An earlier cooperative NWAC station near Mazama (west of Winthrop, Washington) was relocated into the Arrowleaf development area two years ago.
Unfortunately, with last spring's demise of Arrowleaf Corporation, the site had to be relocated again over the summer and early fall of 2000. Mark worked with management of the Freestone Inn and North Cascade Heli-Ski to arrange for a new site near the Freestone Inn and the nearby base of the heli-ski operation. Subsequently Kenny and Garth erected a new weather tower near Freestone Inn, after Freestone Inn and staff (especially Jim Gregg) kindly poured a concrete foundation for the new tower. Instruments were then moved from the old tower site near the Methow River to the new tower adjacent to Jack's Cross Country Cabin near the Freestone Inn, several miles east of Mazama. The Freestone Inn also graciously provided electrical power and

a phone line for remote site access. Since its installation the hourly data has flowed almost flawlessly with the exception of a minor relocation of the 24-hour snowfall sensor out from underneath the total depth sensor. The site is an excellent example of the positive effort possible between the government and the private sector.

Snoqualmie Pass—

In prior years, NWAC access of data from the cooperative WSDOT-Snoqualmie Pass weather system was via hourly transmission of appropriate weather data files from the WSDOT access and scheduler computer to the NWAC scheduler computer via a BBS (Bulletin Board System). The data was then scanned and formatted each hour by a batch file running on the scheduler at NWAC. Then in the fall of 2000, WSDOT avalanche technician programmers converted the Snoqualmie Pass weather data system from their scheduler controlled system into a more open phone modem to datalogger to RF modem accessed system. This allowed NWAC to directly access several phone modem and radio frequency weather sites near the Pass and we in turn provided assistance in troubleshooting, installation and replacement of several sensors, as well as helped with installation and automated information display on our web site. These coop sites are largely managed and maintained by WSDOT avalanche technicians at Snoqualmie Pass, and include stations immediately adjacent to the Avalanche Control office at the Pass (air temperature, radiation, total snowdepth 24-hr snowfall, and precipitation), a higher elevation RF station for temperature and winds at the top of the Snoqualmie Summit (West) ski area, an east side RF linked station above the East Side Snowshed avalanche path, and a final RF linked station on Mt Washington about 10 miles west of the summit. The Mt Washington site has temperature and wind direction, both useful in tracking the depth and erosion of cold air during warming episodes flowing over a cold easterly pass flow. Once the new method of data access was implemented and the necessary file changes initiated for formatting, display and archiving of the data at the Avalanche Center, the data retrieval and display process went surprisingly smoothly. Data form new total and 24-hour snow depth gages provided by NWAC correlated very closely with manual depth observations by WSDOT personnel, normally within an inch or so of the actual measurements.

Alpental—

After initial construction late last spring, in November the ski area and WSDOT provided the Avalanche Center with the rest of a new tower at the base of the ski area. While some accoutrements still need to be added to the tower (like a rail and some more permanent sensor mounts), with the help of WSDOT personnel NWAC staff completed the installation of a new base station for Alpental in late November. This station included a Campbell CR10X data logger, Judd automated total and 24 hour snowdepth sensors and a Campbell temperature/relative humidity probe. Use of an existing heated precipitation gage continued, but it worked well throughout the winter. The site was possible through the cooperation of both the WSDOT avalanche crew and the ski area. The ski area contributed the electricity necessary for power and heating the precipitation gage, while WSDOT and the ski area personnel helped in maintaining and troubleshooting any problems with the site. Most of our weather sites are possible and function better largely because of such cooperative efforts.

This new site eliminated many of the problems associated with trying to telemeter sensor data from a variety of stations over potentially long line runs to a single data logger. And as has been proving to be the case at many NWAC locations, conversion to data loggers located at each of several primary sensor locations seems to be a more reliable though slightly more expensive alternative than trying to run several sub-sites through long line runs from one data logger location. The main increases in costs associated with such an alternative are from new phone line(s) (about $25-35/month), additional data loggers (~$1,100) and phone modems (~$300). And there is a significant amount of additional programming required for rewriting data logger programs and the programs necessary to merge, process, format, and display datasets at NWAC. Despite these costs—which are often shared between NWAC and the ski area or other cooperator—this monetary increase can be partially or fully offset by a combination of reduced maintenance requirements (fewer site repairs) and higher quality and more reliable data.

Tumwater—

The cooperative WSDOT/NWAC Tumwater site experienced a series of data related problems throughout much of the 1999/2000 winter. The most prominent problems included little or no precipitation or snowdepth data as well as intermittent RF link problems. It was thought that these problems could be mostly easily resolved through installation of both a new micro logger and depth sensor at the site, with the precipitation gage probably needing replacement of the catalytic beads as well as new propane supply lines. As a result of these problems, forecast staff cooperated with WSDOT avalanche control personnel from Stevens Pass to both troubleshoot and replace the affected sensors and/or data loggers. In early November Mark and Kenny met with the WSDOT avalanche technician Mike Stanford and drove/hiked to the Tumwater ridgeline. In order to try to standardize the field data network, they replaced an aging CR21x logger with a new CR10X logger, rewired the system and replaced an old malfunctioning acoustic snowdepth sensor with a new Judd-2 depth gage. They also checked propane lines and prepared the site for a resupply of propane later in the winter when the site could be accessed by snowcat. It is almost pointless to mention that there are few sensors more useless than an unheated precipitation gage at a mountain station during the winter. While a very meager winter did not allow for the resupplied propane to arrive at the site, the changes that forecasters and WSDOT personnel collaborated on at the site in November allowed for much improved quality and quantity of data throughout the past winter (with the exception of precipitation).

Mt Hood Meadows—

As a result of sporadic problems that developed with the total depth gage late in late March of 2000, the gage was subsequently replaced—however it was not a straightforward swap. First a direct replacement of an old version of the depth gage was tried. After this failed to fix the problem, several newer versions of the depth gage were installed, with the newest version finally being the one that worked for most of the winter. This necessitated a significant rewrite of the data logger program, but this is minimal work when good data results! Now late this past winter the wind speed sensor appeared to be under recording winds in most situations. Following these fixes the Mt Hood Meadows weather site operated reliably for most of the season until late March when the speed sensor began under reporting expected speeds. Subsequent investigation by the ski patrol indicated that the bearings were “sticky”—probably indicating overheating and needing replacement. Forecasters plan to swap and then repair the

rotor later in June. One continuing problem regarding the 24-hr depth gage (and acoustic depth gages in general): they are often so reliable that ski patrollers may cease their normal manual observations in lieu of just reading the data off the digital file. This is not the reason such gages were installed! They can augment human observations, and indeed replace such observations overnight or when most observers are off on active avalanche control. But in most instances they are not installed to replace regular daily manual observation programs. The only time automated weather stations should actually replace manual observations is if the manual program is discontinued.

Chinook Pass—

Two summers ago the WSDOT avalanche control crew team from Snoqualmie Pass provided invaluable assistance and initiative in reinstallation, repair and relocation of the older heavy snow (record snow year of 1998/99) and high wind damaged Chinook Pass knob and precipitation instrumentation towers. While snow creep from the winter of 1999/2000 produced minor down slope leaning of the precipitation site tower, the WSDOT crew once again responded and pulled the tower back to vertical with the aid of a nearby tree, wire and come-along. Unfortunately, after a very successful winter of operation in 199/200, the radio frequency (RF) link from the base station at the top the Crystal Mountain ski area to the two remote sites experienced significant and generally increasing problems both late last spring and intermittently throughout this past winter. Forecasters are planning on climbing to all three sites and removing the radios and RF modems for analysis, troubleshooting and possible repair by Campbell Scientific's radio engineers over the summer. If the radios are deemed unserviceable, then new radios and RF equipment are planned for installation late in the summer or next fall to help ensure a trouble-free winter.

Also, after tightening and fixing several leaks in the propane supply line from the bottles to the gage last fall, the propane heated precipitation gage operated well for over three months (late November through February. Nevertheless, it is hoped that an enhanced remote precipitation gage can be developed soon to help lengthen the time and reliability of rain/snowfall measurement at non-AC powered remote sites. To this end, NWAC staff are cooperating with a local instrumentation engineer to develop an improved gage. Finally, on an explosives helicopter supply flight for Chinook Pass avalanche control this past spring, the WSDOT avalanche crew arranged to fly in several replacement RV batteries for the difficult to reach Knob site. Cudos to the WSDOT crew for all of their invaluable and continued assistance on the maintenance and troubleshooting of this site. This RV airlift meant that forecasters will not have to hike in RV batteries when they visit the site for radio work this summer. Yahoo!

Crater Lake—

NWAC worked closely with Oregon State University and Crater Lake NPS during the fall of 1999 to complete and enhance the Crater Lake remote weather station. With the strong support of OSU, temperature and wind information from the OSU Crater Lake rim site was added to the Crater Lake telemetry data, and OSU added a new total snow depth sensor to the rim site last summer. With the exception of intermittent problems regarding the rim snow depth (possibly due to the wind knocking the sensor off horizontal axis or rotating the depth gage pole), data from the site was generally reliable and helped NWS and NWAC forecasters as well as the public, with over 18,000 web hits recorded on the site data file during the past winter.

Forecasters are planning on an annual site maintenance visit either this summer or fall, and may return later in the fall or early winter for an avalanche/mountain weather training session.

Timberline—

Major changes occurred with the Timberline Weather display system in the summer of 1999, most of these necessitated by a hard crash of the attached weather computer display system and associated difficulty in both programming and remote troubleshooting of the weather site and in hourly retrieval of the data. Originally, the weather system had been initiated as part of a cooperative effort between the local Zig-Zag Ranger District, Mt Hood National Forest and NWAC to enhance visitor safety on Mt Hood. One of the components of this information system was an automatically updating (every 5 minutes) computer display of local weather data on the mountain, which was housed in the Climbing Register cubicle at Timberline and attached directly to the system micro logger. Due to a variety of mainly power related problems and surges, the local display computer had experienced increasing downtime in the winters of 1997/99 and 1998/99, requiring several replacements and repairs, and producing significant loss of data during these outages. Finally, with a major hard drive crash in the fall of 1999, forecast staff disconnected the computer and removed it from the telemetry system, instead calling directly into the data logger and interrogating it like most other sites in the data network. Climbers and other users and cooperators were then able to view this information more reliably over the Internet, and indeed they did, with the data file receiving almost 20,000 hits in the winter of 1999/2000 and over 35,000 hits last winter. More reliable operation was also possible through installation of a new UPS provided by the local Forest Service Ranger District (Zig-Zag) in the summer of 1999. Special thanks are in order for one of the staff—Bruce Haynes—who has always contributed considerable time and energy to the project. Several winters of harsh operation conditions apparently caused bearing and heater damage from both wind speed and direction sensors at the 7000 ft level. To fix this problem, new sensors were shipped to the ski area maintenance personnel, with the mountain manager Bill Brett kindly helping and arranging for the sensor swap.

This spring lightning damaged the DC power supplies for almost all of the temperature sensors, making them read about 10-20 degrees F low. Lightning also damaged the power supply for the 6000 ft (609 m) wind direction and may have resulted in the intermittently bad readings for the 7000 ft direction. An early summer trip is planned to the Mt Hood area to repair these damaged power supplies, check fuses and in general correct any faulty sensor readings. However, bigger and better things are in store for the Timberline weather data system as a whole.

In order to minimize the agony, frustration and sensor/system outages associated with long sensor line runs, NWAC staff are planning significant changes to the Timberline weather system this summer and fall. First, a new weather study plot is planned for the 6000 ft (609 m) level, and NWAC staff are cooperating with the Timberline ski area to install and instrument the new weather station near the existing ski area total snow stake and study plot. This will entail pouring a concrete base for the tower and running necessary power and telemetry lines from the top of the nearby Pucci chair. The existing datalogger will be moved from its current Climber's register location to an enclosure on the tower, with an AC and telemetry junction box installed on the tower as well, along with sensors for air temperature, relative humidity, electrically heated precipitation, total snow depth (and perhaps 24-hr snowdepth). Wind speed

and direction data will be run from existing sensors on the top terminal of the Pucci Chair lift, and an extension of the existing Timberline telemetry phone line will be routed from Timberline Lodge to Pucci chair and the new site. While the air temperature from the bottom of the Pucci chair will be retained to help produce a vertical temperature profile near Mt Hood, in general this reconfiguration of the base telemetry should greatly alleviate the problems associated with long line runs and the myriad of junction boxes that comprise the current system.

The second part of the revamped Timberline weather system will be the addition of a new datalogger and phone line at the top of the Mile chair lift. This logger will sample upper winds and temperature at the 7000 ft / 2134 m level as well as temperature at the 8000 ft / 2438 m level. The close proximity of sensors to datalogger should once again greatly lessen any problems associated with long line runs. The combination of new/revised loggers should limit long line run problems such as breaks, shorts, induced voltages, etc and should limit or eliminate lightning or higher voltage related damages. Hopefully merging these two data sets back at the Avalanche Center will produce a reliable and accurate source of mountain weather information for the south side of Mt Hood.

Government Camp—

Although considerable energy and work was directed toward getting the Government Camp station (located within the Mt Hood Ski Bowl ski area) up and operational two winters ago, continuing land line problems within the ski area prevented reliable data acquisition from the base study plot. However, after reworking data cables and replacing blown fuses, upper air temperature and winds were the most reliable in some time during the past winter, as the only remaining signals left to transmit over the sporadic and unreliable telemetry cables within the ski area were the phone tones. To provide for long term resolution of frustration and data outages associated with telemetering sensor data over long line runs, forecasters are planning to add an additional data logger and phone line to the base study plot the summer along with construction of a new precipitation / temperature / snowdepth tower. This should allow for accurate and reliable hourly data from the base of Ski Bowl, including air temperature, heated precipitation, relative humidity, and total snow depth—see also the major planned changes section below.

Mission Ridge—

With the excellent support of the Mission Ridge ski area and their cooperative weather system (NWAC is sharing several sensors with the ski area to provide for reliable weather data throughout the mountain), the Mission Ridge weather station once again proved to be one of our most reliable cooperative data sites. Data from this system was reliable and accurate and provided forecasters with good insight into the at times data sparse Cascade east slopes.

Washington Pass—

The satellite to FTP communication link for the weather site at Washington Pass has operated admirably for most of the past two winters, with the data automatically transferred from an FTP

site operated by the WRCC—Western Region Climate Center (this following a season of intermittent data availability through modem link access of this weather data set in the winter of 1998/99). The FTP access provided better security and a more reliable data link for WRCC and the Avalanche Center. While the precipitation gage ran out of propane after about three months, precipitation data was still an improvement over the previous season, and the automated snowdepth sensor operated almost problem-free for the entire winter. Even so, the propane gages seem to be intermittent in terms of operation and heating. As a result, and as mentioned above in the discussion of remote precipitation measurement at both Tumwater and Chinook Pass, NWAC is continuing to cooperate with a local instrumentation engineer to try to help design a more reliable remote precipitation gage. Other vendors are also devising several other designs for remote precipitation measuring, but none seem to be more reliable then existing sensors, at least not yet. Some possible alternatives include cumulative gages with pressure transducer measuring the change in pressure head as new precipitation accumulates in some sort of ethylene-glycol or other anti-freeze solution, or an enhanced design for better propane heating of the gage and funnel. While NWAC tried a new pressure transducer-cumulative storage gage at Washington Pass during the last winter, problems with interfacing the data readout with an old Handar datalogger proved to be very difficult and provided inconclusive data. It is hoped that a change to a Campbell Scientific datalogger and either an RF or meteor burst system this next year will allow for better precipitation measurements, either in conjunction with an enhanced propane heated gage or the cumulative storage gage.

Also the wind speed and direction sensors need to be replaced this summer or fall as unreliable readings from both sensors became more obvious late in the winter. These sensors have not had maintenance or been replaced for several years and are overdue.

Hurricane Ridge—

Last summer the NPS provided NWAC with some much needed tree pruning near the wind tower, which allowed for much more representative wind speeds and directions at this normally wind exposed site. The NPS radio tech shop and the Park also provided NWAC use of a new microwave linked phone line, which allowed forecasters to install a new Campbell CR10X datalogger and some associated new sensors. Mark and Garth completed this work in late November, along with installing a Judd automated snowdepth sensor and a new air temperature/relative humidity (ATRH) probe. Although much better and a wider range of data was available over this hourly phone line link, the snowdepth and precipitation sensors still suffered from a wind tunnel effect created by windflow between trees and the generator building. This limited the usefulness of data from this valuable site. It is hoped that installation of a new and better situated precipitation/snow depth tower will address some of these site issues, if construction is allowed either this summer or next.

Fortunately, thanks to the great efforts of the volunteer Hurricane Ridge observer John Charno—with some of the data observed even during rehab of a shoulder injury—reliable manual weather and snowpack data was received almost daily throughout the winter. These manual observations provided much needed on-site data which greatly aided forecasters in both weather and avalanche forecasts for the Olympics.

More recently this spring, Mark worked with the Park to allow integration of a new Handar satellite datalogger into sampling sensor data from the current weather system. Currently both datalogger based systems—one microwave phone link and one GOES satellite link—are working well.

From NWAC experiences with the remote weather data network as described above, several significant instrumentation or datalogger changes for the better are planned for the summer and fall prior to the start of next year. These changes summarized below are in addition to the normal troubleshooting, maintenance and repair of data site components that occurs every year. While some of these enhancements are listed in more detail in the descriptions above, a short summary of these improvements is in order.

Major Planned Changes to Remote Date Network—2001/02:

1. **Mt Baker**—if possible change from meteor burst to (microwave based) phone telemetry system. Add wind speed and direction from the top of the Pan Dome chair (C-1) if possible. Eliminate the old satellite based weather system if phone line system becomes available.
2. **Crystal Mountain—**add heated wind speed and direction sensors to tower at mountain top restaurant. Work with ski area to provide 120-V AC exterior outlet on tower. Work with ski area to potentially automate and instrument upper elevation study plot (Green Valley) with new phone line to study plot. Plot would have 24-hour and total snowdepth, air temperature, and possibly precipitation.
3. **Stevens Pass Ski Area—**work with ski area to finish new base study plot site with automated precipitation, air temperature, relative humidity, 24-hour and total snowdepth. Also help ski area in relocation of wind speed and direction sensors from old phone pole near top of Skyline Chair to new tower to be installed at top of Brooks Chair after the top lift station and unload platform are refurbished and regraded. Work with WSDOT avalanche crew to possibly remove old Grace Lakes/Old Faithful weather system once new NWAC/ski area weather system is complete and data analysis of wind information accepted. This change should allow for much easier maintenance costs over the long term.
4. **Mt Hood Ski Bowl—**work with ski area to install new data logger/phone line at ski area base. This would allow for hourly heated precipitation, air temperature, relative humidity, and total snowdepth at the base to be integrated with other upper elevation data for this site. Such a conversion to two separate datalogger sites should go a long way toward eliminating all of the consistent land line problems that have rendered base area data useless for the past several years.
5. **Timberline Lodge/Ski Area—**work with ski area and Forest Service Zig-Zag Ranger District to install relocate data logger/phone line from Climber's Register area to new study plot and Rohn 45G tower to be constructed at ski area study plot near top of Pucci Chair. A second datalogger would be installed at the top the Magic Mile chair lift to accommodate upper winds and temperatures from the 7-8,000 ft levels. This should eliminate long line run and induced DC/AC problems that have plagued this site in its current configuration for several years. The relocated lower logger would sample heated precipitation, air temperature, relative humidity, wind speed and direction, and total and

24-hr snow depth from around the 6000 ft level, and perhaps still sample an air temperature from the 5300 ft level (base of the Pucci Chair). This would allow for future removal of the old tower and propane heated precipitation system at the base of the Pucci Chair.

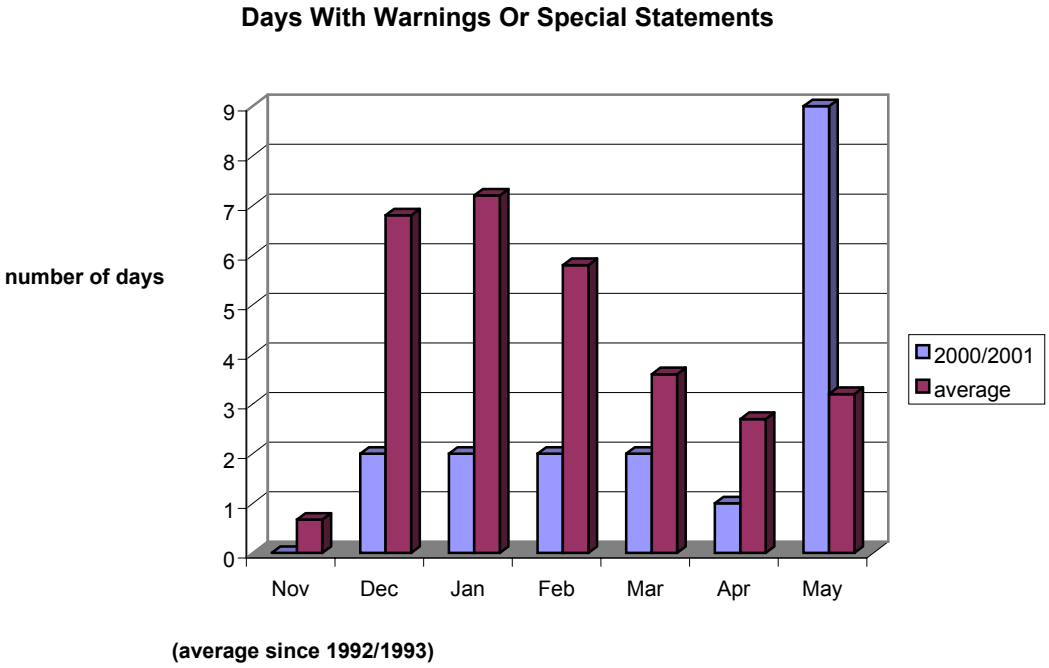
6. **Washington Pass/Chinook Pass—**depending on the disposition of the planned microwave phone line at Mt Baker, consider the possibility of replacing satellite based telemetry system at Washington Pass with the meteor burst telemetry system removed from Mt Baker. Also add a new enhanced propane heated precipitation gage if available.
7. **Hurricane Ridge/Olympic National Park—**working with the Park, consider relocation of total snow depth sensor and possibly precipitation gage to a less wind affected area. May have to add new sensors for fire-weather based satellite datalogger—e.g., wind speed and direction, fuel moisture and fuel temperature. Still possible to common precipitation gage measurements and perhaps winds to both loggers as has been done for the past 6 months—however may be preferable to have separate sensors if time and budget (NWAC and fire-weather) allows.

OFFICE OPERATIONS

Warnings And Special Statements

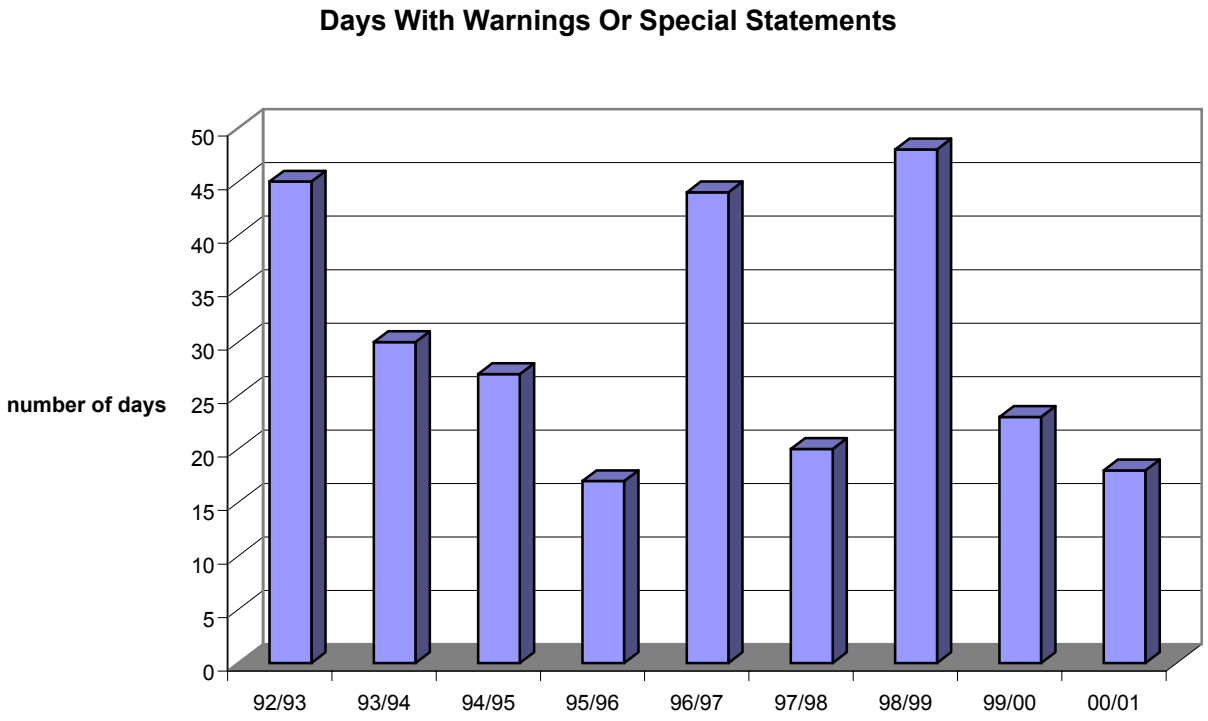
With the less than usual storm cycles and snow the past season, the number of warnings we issued was also below normal during the winter months.

Figure 20. NWAC Warnings and Special Statements by month



Only 2 warnings were issued each month between December and March, with only one warning in April. The heavy snow at the start of May reversed this situation, and we issued a much greater than normal (9) number of special statements in early May. The number of days with Warnings or Special Statements this season (18) was also below average. Normal is about 25, and without the nine special statements in May, this number would have been much below normal.

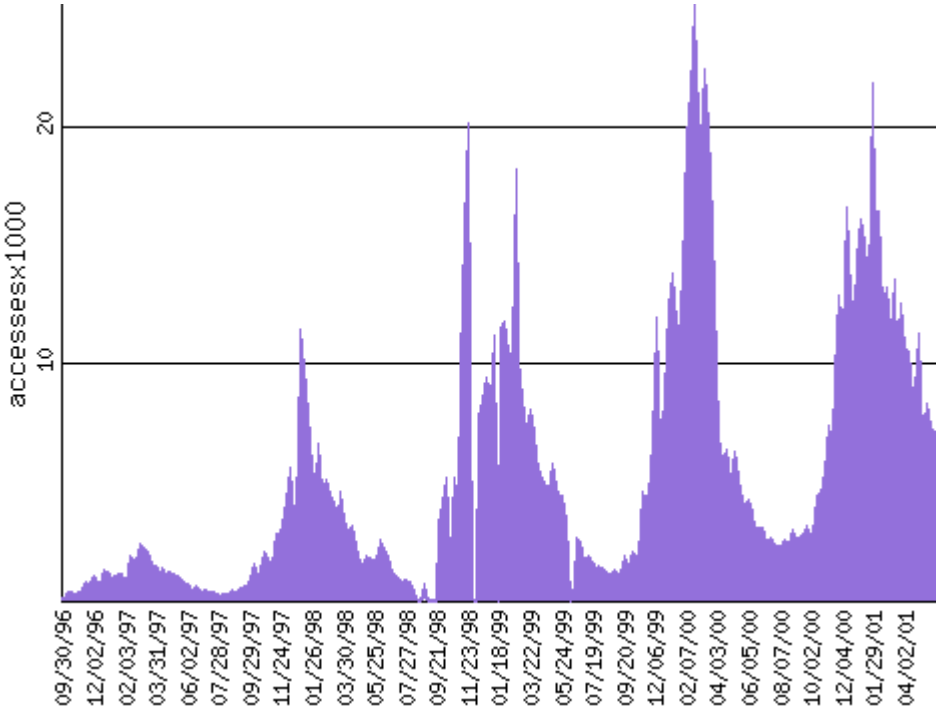
Figure 21. Annual Warnings and Special Statements—1992-2001



Internet Hits And Phone Calls To Nwac Products

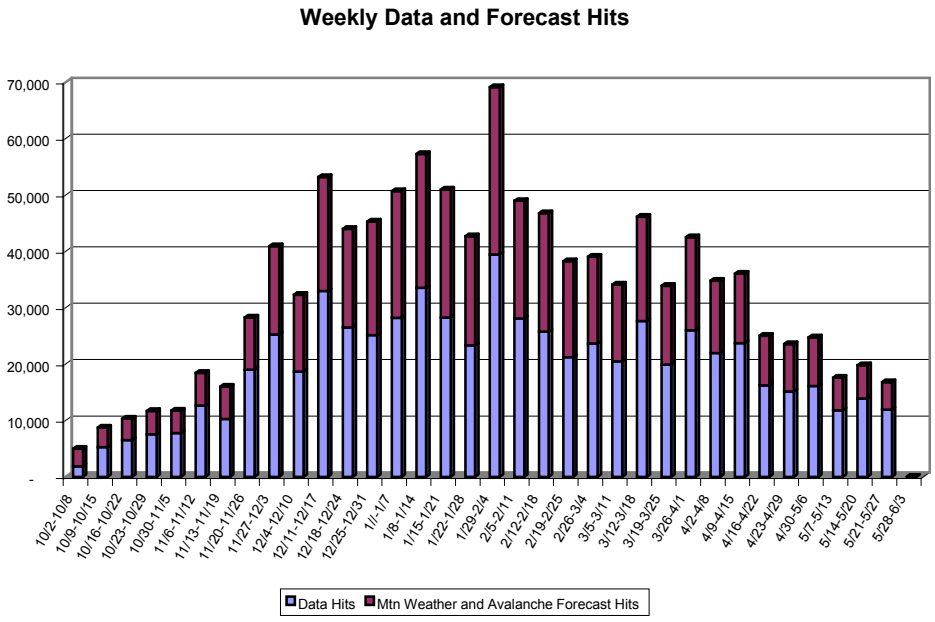
Internet access to the NWAC web site continues to show a dramatic increase since its inception in 1996. As the following figure showing NWAC web site history from 9/30/1996 to 6/3/2001) shows, access to the web site has not only increased overall but the usage has broadened in terms of access outside the normal winter months—and this during a less than spectacular winter.

Figure 22. NWAC Internet Site—home page visits from inception to present (09/96-06/01)



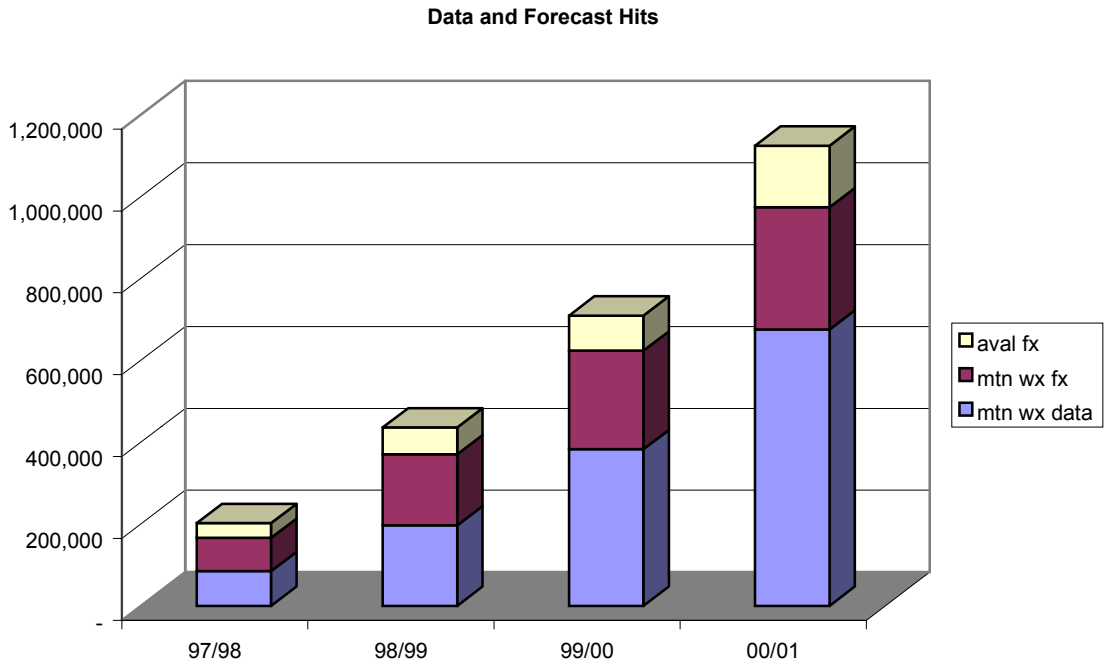
Hits on specific data and forecast products are also showing dramatic increases, with weekly hits on data and forecast products shown in the following figure.

Figure 23. Weekly Hits on NWAC Data and Forecasts—2000/01



Weekly hit totals probably tended to vary with storm cycles in the mountains. Strong increases in hits appear to correlate with significant storms and snowfall, which occurred around the end of November, mid December, and early February. Weekly hit totals of over 50,000 were seen during several weeks during the season. Total data and forecast hits for the most recent and previous 3 seasons are shown by the following.

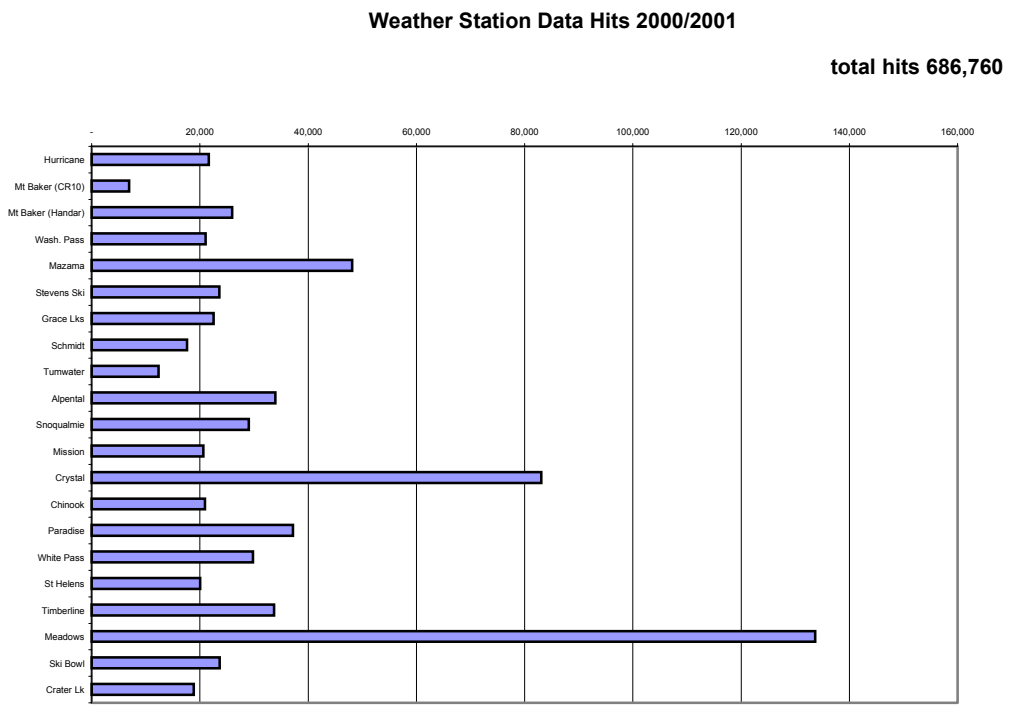
Figure 24. NWAC Annual Data and Forecast Hits—1997-2001



Roughly linear increases of about 200,00 were seen between the first 3 seasons data was available on the Internet. But the increase in Internet hits doubled to over 400,000 this past season, with the **total of data and forecast hits reaching over 1.1 million** during the past winter (October 2-June 4) At that rate of change NWAC forecast and data products could see nearly 2 million hits next season. It will be interesting to see, especially if the forecasts and data products can be displayed more graphically as is hoped.

We also decided to include a graph of hits to individual weather station data files in this seasons report.

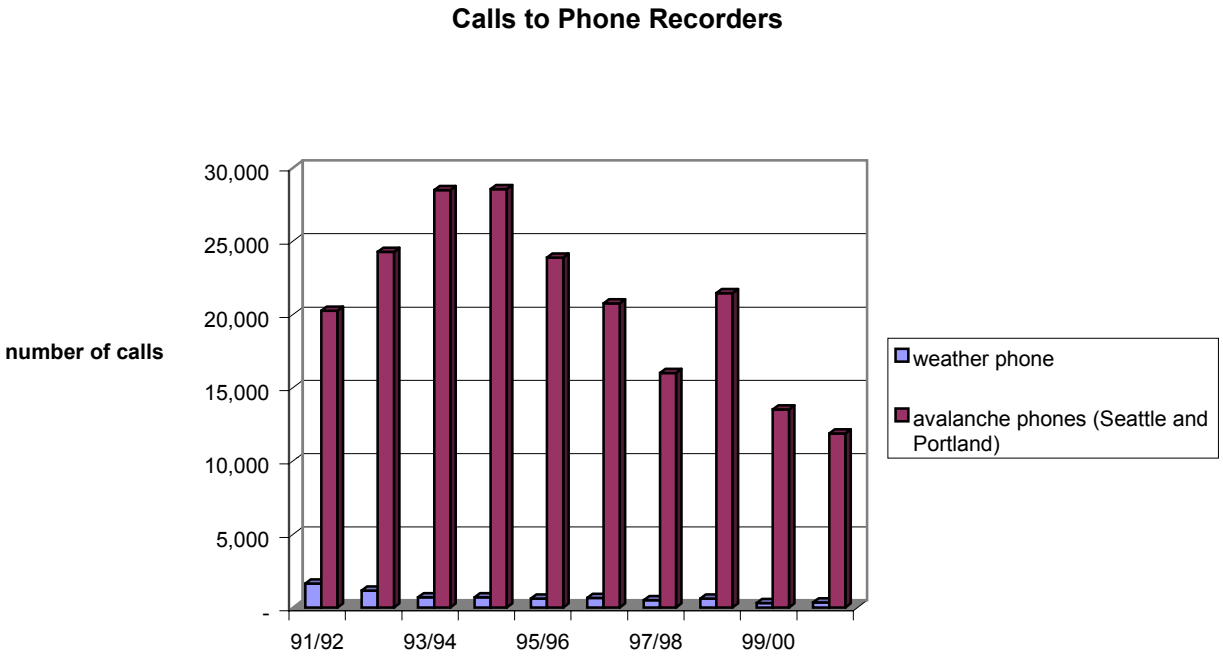
Figure 25. Hits on Individual Weather Stations—2000/01



The Mt Hood Meadows weather data file received by far the most access with over 130,000 hits recorded, and Crystal Mountain received over 80,000. This might be surprising at first, but remember that Mt Hood Meadows is a primary ski area for all of the Portland area. The Mazama data site had over 45,000 hits, probably partly from people interested in XC trail conditions in the Methow Valley. Most other sites received about 20,000 to 30,000 hits. If one were to add the number of hits for all the areas that serve the Puget Sound area (the Stevens Pass sites, the Snoqualmie Pass sites, and Crystal Mountain) then this total would be around 200,000, more than Mt Hood Meadows.

With the vast increase in web site access of all of the forecast products, it is not surprising to see a trend toward decreasing numbers of phone calls to NWAC recorders in Seattle and Portland and this downward trend continued over the past season, although only slightly from last season.

Figure 26. Annual Calls to NWAC Hot lines—1991-2001



An exception to this trend the past few seasons was the heavy snow season of 1998/1999. Certainly this decrease remains due to the availability of NWAC products on the Internet. But phone calls over the past season remained well over 10,000, with the most calls per week recorded in mid-late January and early-mid February-probably from those folks still hoping that winter was still on its way. Although calls to the recorder with the weather forecast also declined, plans are to maintain this service for cooperators without Internet access.

Office Equipment

Two new IBM computers for the NWAC office (PIII-650 mHz machines with robust hard drives and 17-21 inch monitors for aging eyes) arrived in early December. These new computers were gradually integrated into the operational scheme during the past winter and more integration is scheduled to occur this summer and early fall. One of the new computers, with a large 21 inch monitor, will be used mainly for forecast preparation and dissemination, or more graphic intensive work such as digitizing slides and other images. The other new machine will become the new scheduler computer this summer, which will replace the current scheduler computer that does the automatic hourly retrieval of data from dataloggers at our weather stations. With this system we plan to switch to using Campbell scheduling software for data retrieval, and to new "STROV" software for transferring the data to the Internet, as well as for displaying and archiving the data.

Also a new laptop computer was purchased last fall after a Technical Approval from the Supervisor's Office last year allowed for off-contract purchase. After much research into what to buy, it was determined that the best laptop for both field and office work was an IBM—however the lightweight and versatile Thinkpad T20/2647 that was not on the Forest Service contract. To date, the IBM laptop has been increasingly used in the field for programming field data loggers and for writing avalanche and weather related documents while on the road. And it can be used for upcoming presentations when computer projection equipment is available that allows for Powerpoint or other graphical computer based presentations.

Besides the new equipment, we continue to make use of several other Pentium grade machines for our daily work in our office—several of which were supplied by the north-central district of WSDOT. Perhaps more importantly, the National Weather Service has continued to grant us use of their AWIPS computers in the main forecasting area adjacent to our office. This is the second season we have had use of this system which we use to view numerical weather model data, radar images, satellite images, weather observations, and other data. Certainly the AWIPS system is an integral part of our daily forecasting operations. With the National Weather Service also shifting toward PC based graphical workstations for display of weather forecast models, graphics and satellite images, it is hoped that with monetary FOAC support over the summer NWAC will be able to procure an advanced workstation for a local display of weather graphics in the NWAC offices. This would allow forecasters to be able to maintain more continuous updates on changing weather situations by "looking over their shoulder" while composing the forecasts rather than having to run back to the forecast floor—even if it is only a relatively short walk around the corner.

Daily Forecast Routine

Few changes were made to the daily forecasting routine this season, and staffing levels continued as they has since 1980/81—with three full-time forecasters for the operational season and a total of 2.3 FTE's . See the Appendix for a summary review of both the normal operational schedule for NWAC and a sample daily forecasting routine. For this year regular winter season forecasting began on Thursday, 30 November and ended a bit later than usual on Sunday, 29 April. As in the past, forecasters generally arrived between 0300 and 0330 am, reviewed weather data and forecast models until about 0500 am, composed and then shipped the Mountain Weather Forecast by 0630 to 0700 am. Several discussions with WSDOT, ski area, and NPS snow safety personnel, and private individuals regarding weather and snowpack conditions (including avalanche control results) usually took place between 0600 and about 0800 am. The Avalanche Forecasts were composed and then issued by 0830-0900 am. All forecast products and weather data were then automatically transferred and made available on the Northwest Weather and Avalanche Center web site at www.nwac.noaa.gov. The weather and avalanche forecasts were also recorded on the Seattle and Portland telephone recorders as soon as possible after composing. In between looking at and mentally updating the forecasts throughout the morning, a variety of other office tasks were taken care of until midday, such as administration, data requests, computer and data logger trouble shooting, updating of seasonal summaries, updating precipitation, snowpack, avalanche occurrence and freezing level logs, etc. The morning routine was somewhat repeated in the early afternoon. Another review of new weather information was undertaken in the early afternoon, with an updated Mountain Weather

Forecast (and if necessary an updated Avalanche Forecast) issued by about 3 pm on the Internet and on the phone recorders.

Training

Mark attended the Regional Avalanche Forecast Center meeting scheduled by the National Avalanche Center and Doug Abromeit/Karl Birkeland in late September 2000. At this meeting forecasters from all of the major regional and local avalanche centers discussed a variety of subjects, including standardized terminology, levels of service, better methods of product dissemination, web site design and education. Immediately after this workshop, Mark attended some lengthy all-day meetings of the American Avalanche Association board (previously the AAAP or American Association of Avalanche Professionals) as well as the annual Avalanche Artillery Users of North America meeting. Mark, Kenny and Garth then attended the International Snow Science Workshop (ISSW) at Big Sky, Montana for about a week in early October. The ISSW has been held every 2 years in the western US or Canada since 1978, with the Avalanche Center and Northwest cooperators hosting the last one in Sunriver, Oregon in the fall of 1998. The purpose of ISSW is to bring together snow science researchers and operational personnel in a merging (collision?) of theory and practice. Both researchers and operations personnel attended from Canada, Europe, South America, Iceland, India, Japan, New Zealand, Russia and the U.S.A with Mark acting as chair for a weather applications session. Session subjects included Avalanche Accidents and Human Factors in Avalanches, Computer Models, Snow Stability, Program Overviews, Snow Metamorphism, Explosive Triggers, Rain On Snow, Warning Systems, Rescue, Instruments, Data Management, Avalanche Forecasting, Snow Profiles and Stability Tests, with one session devoted entirely to the almost catastrophic European winter of 1999-2000 that produced several large avalanche accidents and many fatalities. The ISSW also allowed for a meeting between all primary National Avalanche School instructors and discussion of the upcoming fall 2001 school near the Canyons ski area of Utah, just prior to the Winter Olympics of 2002.

Later last fall, the NWAC hosted a 3-day data logger and weather instrumentation training session 24-26 October, taught by Austin McHugh from Campbell Scientific in Utah. The class focused on the programming and use of the Campbell CR10 and CR10X data loggers that are the main type of loggers used by NWAC. Other topics included discussion and troubleshooting problematic communication links (such as RF or modem links) and enhanced usage of the recently released new Windows based software. The class was also attended by former NWAC employee Dr. Sue Ferguson and others from the Forestry Sciences Lab, as well as one of the Washington State Department of Transportation avalanche technicians from Snoqualmie Pass. It was felt that all received a great benefit from attending the class and it has already paid dividends in writing better programs and allowing for a better understanding of both datalogger software and hardware.

Following the Campbell workshop, Niko Weis of the *Survival on Snow* company met with forecasters on the 9th of November for a brief training on avalanche beacon search techniques. He demonstrated hands-on training about faster location techniques for a variety of avalanche beacons. The training was helpful and the knowledge learned will be passed on to students attending Avalanche Center avalanche awareness sessions in the future.

Forecasters are continually training and re-training themselves in the "*art of weather forecasting*" as new methods and products become available through the National Weather Service. Such on-site training is an on-going and necessary process and thoroughly integrated into the psyche of each forecaster. Other training in web site development, java script programming, remote weather station programming, data archiving and data display (both graphical and textual) is being accomplished at a slower pace due to the continual demands of the operational forecasting environment. However, NWAC personnel are hopeful of implementing a more graphical NWAC web-site interface in the coming years that will augment the existing faster loading but primarily text-based site—perhaps existing side-by-side with the older site. Such a transition will be slow as it will necessitate considerable changes in the formatting and display of both forecasts and data products.

Public Relations, Education, Data Requests

Mark began the PR season with a journey once again to the annual Washington State Snowmobile Show on the 21st of October in Puyallup at the King County Fairgrounds! Along with staff from both the CleEllum Ranger District and the Mt Baker-Snoqualmie National Forest, Mark felt that the presence of the Forest Service booth was important, since many issues were discussed with snowmobile users, including avalanche awareness, sharing trails with other users, and voluntary restrictions. A large number of Forest Service brochures about snowmobiler safety, trails information and avalanche awareness were disseminated to interested attendees.

Two fund raisers for the Avalanche Center were sponsored and managed by the FOAC (Friends of the Avalanche Center) group in late November and early December. Drawing cards for public attendance included several raffle items (like snowboards and lift tickets and clothing) as well as the first Northwest showing of a new extreme skiing / snowboarding movie. These events raised several hundred dollars, which FOAC may use to help support weather equipment purchases as well as the educational and other efforts of the NWAC. Mark and Garth each attended one of the shows and gave short summaries of the avalanche forecast program, and some long term guesses about the winter ahead—of course laced with as much humor as necessary to accompany any long term forecasting. The several hundred avid recreationists who attended each showing seemed to mostly enjoy the program. We certainly appreciate the efforts of FOAC on the behalf of the NWAC.

As outlined below, many more presentations were made over the course of the season to various groups, both locally and throughout the Northwest.

NWAC Interviews and Presentations 2000/2001

Date	Organization	#	Location	Speaker
21 Oct	Snowmobile Show	100	Puyallup	Moore
15 Nov	Base Camp	40	Bellingham	Emetaz
16 Nov	FOAC Fundraiser	150	Mountaineers	Moore
5 Dec	Mountaineers	36	Everett	White
8 Dec	FOAC Fundraiser	150	REI Seattle	Ferber
10 Dec	Mountain Madness	10	Mt Baker	Ferber
14 Dec	Mountaineers Winter Travel	90	Tacoma	Emetaz
15 Dec	Mt Rainier Nat. Park	15	Paradise	Moore
28 Dec	KPLU interview		NWAC	Moore
6-7 Jan	NAI - avalanche/weather	45	Crystal Mtn	Moore
9 Jan	Ellensburg XC Club	30	Ellensburg	White
12 Jan	KOMO, KING interview		NWAC	Moore
16 Jan	Mountaineers XC/Snowshoe	30	Olympia	Emetaz
20 Jan	Mountain Madness	10	Blewett Pass	Kramer
20-21 Jan	NAI – avalanche/weather	65	Mt Hood	Moore
24 Jan	Mt Hood Com. College	30	Portland	Emetaz
25 Jan	Mountaineers	37	Everett	White
3 Feb	Informal group	10	?	White
3-4 Feb	NAI – avalanche/weather	90	Crystal Mtn	Moore
3-4 Feb	K. Swanson Aval. Course	35	Mt Hood	Emetaz
5 Feb	Mountaineers Scramblers	200	Mountaineers	Kramer
5 Feb	KSTW – tv interview NWAC Speers-Hayes			
5 Feb	Volcano Rescue Team	30	Yacult	Emetaz
6 Feb	Seattle Weekly – interview		NWAC	Moore
6 Feb	MSNBC – phone interview		NWAC	Moore
7 Feb	U of W Mountaineering Club	28	U of W	White
7 Feb	Mercer Island Library	35	Mercer Island	Emetaz
10 Feb	NAI – RMI Guides	40	Crystal Mtn	Moore
10 Feb	Volcano Rescue Team	20	Yacult	Emetaz
16 Feb	KUOW – radio interview		NWAC	Moore
17 Feb	WA State Snowmobile Club	80	Chelan	White
6 Mar	St Helens Snowmobile Club	42	?	White
14 Mar	Mountaineers Climbing	80	Tacoma	Emetaz
21 Mar	NW Forecasters Meeting	10	Mt Baker	Kramer/Ferber
21 Mar	REI avalanche awareness	40	REI Portland	Emetaz
27 Mar	Mountaineers Scramblers	80	Tacoma	Emetaz
26 Apr	Mountaineers	40	Everett	White
5-6 May	NAI – RMI Guides	50	Paradise	Moore
8 May	Mountaineers	40	Everett	White
9 May	Mt Hood Climbing Rangers	5	Timberline	Moore/Ferber
30 May	Cable News NW		NWAC	Moore
Approximate Total		1800 +		

In mid-December, Mark gave an all-day avalanche seminar to Mt Rainier National Park highway maintenance and ranger staff. This was an interesting course as it allowed first-hand

investigation of the rapidly developing depth hoar layers near the ground of the still shallow snowpack near the Paradise Visitor Center.

NWAC forecasters continued their educational efforts in a variety of ways throughout January, February and March. These educational opportunities included several live TV and radio interviews with ABC, NBC, MSNBC, National Public Radio and others, as well as avalanche awareness presentations for mountaineering groups and other interested individuals. Mark instructed over 240 attendees of five multi-day avalanche courses while Kenny presented a mountain weather primer to over 250 interested individuals at the Mountaineers. Meanwhile both Garth and Kenny instructed at several field-training courses at a variety of locations.

On the 20th and 21st of March, Garth and Kenny attended the annual Northwest ski area avalanche forecasters workshop, this year held at Mt Baker. Beautiful, cool and clear weather enabled forecasters from a variety of NW ski areas and the NWAC staff to see the avalanche terrain that Mt Baker patrollers and avalanche personnel deal with on a daily basis.

Mark, Garth and the ever-enthusiastic Roland Emetaz traveled to Timberline on 8 and 9 May to present and discuss spring avalanche considerations with the USFS Mt Hood climbing rangers. The classroom session began in the Barlow Room with a presentation using overheads and slides, which led to an at times spirited discussion of practical backcountry travel considerations. The group then rode the ski lifts up to about 8500 feet and skied up to about 9500 feet for a look at the snow pack. Although the well frozen snowpack was stable at the time, significant and worthwhile discussions ensued along with practical demonstrations of snow stability evaluation.

On schedule for next fall is the 17th bi-annual National Avalanche School to be held in Park City, Utah from October 28-November 2, 2001. Mark will once again be one of the instructors at the school that is the most comprehensive in the US. It offers lectures, workshop, classroom and field training from a wide variety of excellent avalanche professionals. More information about this training program (cost, location, agenda, registration, etc) is available at the school's web site-- http://www.avalancheschool.org.

For the first time, we have decided to include a list of those we have provided with data from our weather stations. These requests for archived data normally require considerable effort on the part of forecasters, depending on exactly how much data is requested. However, forecasters are pleased to provide the data as long as the time is available for adequately filling such a request.

NWAC Weather Station Data or Other Data Requests 2000/20001

Date	Data	Person/Organization
15 Nov	Several stations, past 5 years	Pam Hayes/Univ. of Wa.
15 Dec	Hurricane Ridge, past 5 years	Amy Hessel/Univ. of Wa.
21 Jan	Mission Ridge, past 3 years	Mike Bourton/ski area
26 Apr	Baker, Paradise snow depth data	Halstead Harrison/Univ. of Wa.
27 Apr	Baker snow depth data	Dave Wallin/W. Wa. St. Univ.
3 May	Chinook, Paradise, 2000/2001	Rob Gibson,/WSDOT
14 May	Mt. St Helens, 1999/2000	Jason Taylor/Portland State Univ.
23 May	Mt St Helens, 2000/2001	Will Sampson/Portland State Univ.

(partial list)

This small but important service has been provided by the NWAC to many individuals and agencies during past years. As can be seen the list of recipients for the past season, the data is usually used for research purposes at the University and College levels. However, several requests each year are made for use in litigation, and requestors must submit a written FOIA (Freedom of Information Act) request to the MBS in order to acquire such data. No matter what the usage, potential users of the data are always cautioned that the data was produced for forecasting purposes and may need to be quality controlled. While forecast staff attempt to keep the data to the highest quality level possible, outages and errors can and do occur despite our best efforts.

APPENDIX 1 –

NWAC and Avalanche Related Articles

Avalanche Experts Article

Avalanche alert Experts say recent weather has created conditions that increase the danger of backcountry snow slides

The News Tribune; Tacoma, Wash.; Feb 8, 2001; Skip Card

Avalanche alert Experts say recent weather has created conditions that increase the danger of backcountry snow slides Byline: Skip Card; The News Tribune Twenty years later, Doug Blanchard still vividly recalls the first time an avalanche swept him down a mountainside. At the time, Blanchard was a first-year ski patrol member working beside a senior patroller who had just set off explosives to clear a slide-prone slope. Blanchard thought the charge had been placed too far to one side, but he wasn't prepared to question the judgment of someone with more experience. Moments later, as Blanchard skied across what should have been a stable hillside, a 14-inch-deep snow layer gave way beneath him. "It was just a small slide, but it sent me somersaulting. I tried to ski out of it but couldn't," Blanchard recalled. As the snow quickly swarmed around him, he flailed his arms in a swimming motion to stay on top of the sweeping snow. Blanchard, now snow safety director for Crystal Mountain's Ski Patrol, walked away with few injuries. But the experience taught him a valuable lesson about avalanches: Trust your gut, and don't travel where training or intuition tell you a slide is likely. That message of caution is one Northwest avalanche experts hope people hear this winter, especially now that storms have brought fresh snow to Washington's Cascades and Olympics and dramatically increased the danger of backcountry avalanches. An avalanche has already claimed one life in Washington this season. Derek Bowen, a 32-year-old East Wenatchee resident, died Jan. 29 after being buried under four feet of fresh snow while snowshoeing in Wenatchee National Forest. Bowen's death was the 12th avalanche-related fatality since 1996 in Washington, where snow slides have killed at least one person in each of the past five winters. People have been killed by avalanches while skiing, snowboarding, snowshoeing, climbing, riding snowmobiles or simply camping in the wrong spot. The circumstances of the accidents vary, but nearly all were caused because people ventured too far into avalanche-prone terrain. "Ninety-plus percent of the avalanches that kill people are triggered by the victims," said Paul Baugher, director of the Northwest Avalanche Institute and director of the Crystal Mountain Ski Patrol. A single skier or snowmobiler on an avalanche-prone slope, Baugher said, can supply the weight that "tips the balance between the stresses on the snowpack and the strengths within the snowpack that resist those stresses," Baugher said. "People are triggers.

People are the difference." In his avalanche safety courses, Baugher teaches how to be alert to avalanche dangers and stay away from slide-prone terrain. Prevention is key, he said, because the odds aren't good for anyone who stumbles into an avalanche and becomes pinned by the crushing weight of snow. More than half the deaths from avalanches occur when the trapped victims suffocate before help arrives. "Once you're completely buried in an avalanche, your chances of being dug out alive are about 1 out of 3," Baugher said. "That's not a very good statistic." Chances of rescue rise when victims wear avalanche beacons that electronically pinpoint their locations, and if their fellow travelers carry shovels and body-finding snow probes. Odds of survival drop dramatically, however, when companions lack proper rescue equipment, can't quickly find buried victims and have to leave to seek help. That happened last week after the slide buried Bowen in the Wenatchee National Forest, Baugher said. "If the rescue cannot be carried out by the victim's companions, that is as much as saying goodbye," he said. "In terms of statistics, that was the last chance." Increasing danger Avalanche dangers were low in the Northwest throughout most of January, when snowpack was about half of normal. Last week, however, a series of snowstorms began to sweep through the mountains. In some areas, strong winds that accompanied the snowfall formed "wind slab," a condition in which snow crystals are broken apart and compacted to form a cohesive layer. "Wind with snow is the biggest element in producing wind slab," said Kenny Kramer, a meteorologist with the Northwest Weather and Avalanche Center. "You have these delicate snow crystals, and the winds break the snow crystals apart into fine particles, then they're deposited on the leeward slopes." Slab danger increases after storms if the fresh snow melts, or if freezing levels rise and mountainsides see rain instead of snow. "That's a guaranteed scenario for dangerous avalanche conditions," Kramer said. Given time and the right conditions, new snow can settle and bond with the older snow beneath it. But until it does, people skiing, snowshoeing or riding snowmobiles across steep hillsides risk adding the extra weight that breaks loose the top slab of snow and sends it sliding down the slope. The break can happen at any time, Baugher warned, regardless of backcountry travelers' schedules or plans. "Humans care about things like, 'I've got to be home by 5' or 'I've got the reach the summit,'" Baugher said. "The snow cares about things like how steep it is, or how much load is on it, or what the temperature is." Many slides occur during sunny days on hillsides that were stable in the morning but grew fragile as temperatures rose, he said. Sometimes, slopes that supported a single snowshoer on the way up can weaken under the weight of several snowshoers heading down. This winter, the danger of more severe avalanches could increase as the new snow bonds to the older, weaker snow layers beneath it, Baugher said. The January snow layer is weak enough to foster so-called "climax avalanches" in which all snow breaks away from a steep hillside. "We can easily have slopes that release to the ground," Baugher predicted. "This year would not be a year to underestimate deep slab instability, even though we don't have it now. "We may have to pay the piper for getting our storms late," he said. Safety tips, training Avalanche safety courses offer the best way for people to learn how to avoid dangerous areas. Several courses are taught each winter by private instructors or local outdoor clubs such as The Mountaineers. "There's no substitute for training," Baugher said. For those who prefer to study on their own, at least five books on avalanche safety are available in stores. Safety equipment such as avalanche beacons won't prevent a slide but will increase the odds of rescue. Beacons typically sell for between $250 and $300 at stores such as REI. Many backcountry travelers carry lightweight shovels, which often cost between $29 and $60 depending on size and weight. Collapsible metal snow probes, which resemble high-tech tent poles, sell for between $60 and $80, depending on their length

and materials. Avalanche experts also advise backcountry travelers to monitor weather forecasts and listen for avalanche alerts. The Northwest Weather and Avalanche Center offers recorded information at 206-526-6677. Detailed weather information is posted daily on its Web site, www.nwac.noaa.gov. Skiers and snowboarders who stick to maintained ski resorts typically have little to fear from avalanche dangers. Ski patrols monitor conditions at resorts and often blast explosives to release unstable snow before it swallows paying customers. At Crystal Mountain, senior patrol members such as Baugher and Blanchard head off each morning with other patrollers to identify slide-prone areas and blast them into submission. Mornings often begin with patrollers threading fuses into bright yellow tubes the shape of paint rollers. The tubes contain ammonium nitrate, the same explosive chemical used in the blast the destroyed the Oklahoma City federal building in 1995. Blanchard said each tube is equivalent to two or three sticks of dynamite. It's the shock wave from the explosions - not the sound - that knocks snow slabs loose, Baugher said. The idea that noise alone can trigger an avalanche is an old wive's tale, he said. Patrol members ski out to slide-prone areas, light the fuses and drop the charges into potentially unstable snow - or, for even greater effect, place the charges about a yard above the snow's surface. Ninety seconds later, a sharp blast echoes off the mountainsides, and a wave of loose snow surfs down the hillside. After the explosives have been detonated, the patrollers still monitor the mountain and keep watch for accidents. Most patrols also keep search dogs trained to sniff out people buried in snow. All of the recent avalanche-related deaths in Washington have occurred when skiers and snowboarders entered closed areas or traveled beyond ski areas' boundaries. Experts warn that avalanche risks can be reduced but rarely eliminated. Even ski patrol members, trained to watch for avalanches and avoid dangerous slopes, aren't immune from danger. Saturday at Crystal Mountain, a patroller investigating an avalanche outside the resort boundary found himself caught in a slide. The patroller used his training and athletic ability to keep from being buried. Meanwhile, a companion was ready nearby with a shovel, avalanche beacon and snow probe. Avalanches are so common that the situation isn't unusual. Most ski patrol members typically find themselves caught in a slide if they spend enough years in the backcountry, Blanchard said. "It's like the longer you do it, the higher the probability is," he said. - - -

- SIDEBAR: Recorded information The Northwest Weather and Avalanche Center provides weather information and avalanche advisories for backcountry areas of the Washington Cascades and Olympics. Recorded information, updated daily, is available at 206-526-6677. - - -
- SIDEBAR: On the Web * Northwest Weather and Avalanche Center: www.nwac.noaa.gov. * Northwest Avalanche Institute: www.avalanche.org/~nai. * Forest Service National Avalanche Center: www.avalanche.org/~nac. * Avalanche safety tips from Idaho State University: www.isu.edu/outdoor/avahints.htm.
- SIDEBAR: Courses Paul Baugher and the Northwest Avalanche Institute based at Crystal Mountain offer beginning and advanced courses in avalanche safety each winter. For information on current courses, call 360-825-9261. Longtime backcountry skier Gary Bill will conduct a three-evening seminar on avalanche safety. Lectures will be from 7 to 9:30 p.m. Feb. 20, Feb. 27 and March 1 at Backpacker's Supply, 5260 South Tacoma Way. The course also includes one field session. Cost is $125. Registration information is available at Backpacker's Supply.
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- SIDEBAR: Instructional books "The Avalanche Handbook" by David McClung, with Peter Schaerer (Mountaineers Books, $19.95). "Avalanche Safety for Skiers, Climbers and Snowboarders" by Tony Daffern (Rocky Mountain Books, $11.95). "Snow Sense: A Guide to Evaluating Snow Avalanche Hazard" by Jill A. Fredston, Douglas S. Fesler, Doug Fesler (Alaska Mountain Safety Center, $8.95). "Avalanche Aware" by John Moynier (Falcon Publishing Co., $6.95).

- Staff writer Skip Card covers outdoor recreation. Reach him at 253-597-8655 or skip.card@mail.tribnet.com. - - -

Avalanche and Clear Warnings Article

Top stories in The Columbian
columbian.com

AVALANCHE - MOUNTAINS GIVE CLEAR WARNINGS, EXPERTS SAY

Tuesday, March 20, 2001
By ANNIE PIERCE RUSUNEN, Columbian staff writer

The mountains are full of warning signs.

Roland Emetaz says smart mountain climbers and backcountry explorers take the time to read these natural clues.

Avalanches lurk in pristine mountain terrain, yet many people venture out without proper training and don't heed the mountain's warnings, Emetaz said. Avalanches have thundered down slopes claiming 22 lives in the United States so far in the 2000-2001 season, according to the Northwest Weather and Avalanche Center.

This spring could be particularly dangerous in the mountains as this winter's shallow and generally weak snowpack is susceptible to a rapid decrease in stability if temperatures rise.

"This year could be more dangerous than most if we have a sudden warming," said Emetaz, noting that if temperatures rise into the 70s, backcountry travelers should avoid steep snow slopes.

Emetaz, a retired U.S. Forest Service professional and avalanche expert from Vancouver, says he wants to sharpen people's "avalanche eyes."

To do that, he's hosting a free avalanche safety workshop at 7 p.m. Wednesday at Portland's Recreational Equipment Inc. (REI). The introductory workshop and slide show will include basic information about avalanches and tips on using avalanche safety equipment.

Emetaz will discuss avalanche warning signs and will give demonstrations on searching for avalanche victims. Although there's no simple way to spot avalanche-prone areas, packing proper equipment and knowing what to look for can improve the chances for back-country travelers.

NWAC reports that only 20 to 25 percent of people who buy back-country gear also buy safety equipment, including avalanche beacons, shovels and probes.

"It's important to constantly develop your avalanche eyes, to look at the conditions around you," Emetaz said in an avalanche lecture he hosted last year. "You can always decide to turn around if the conditions seem dangerous. The mountain will always be there to climb another time."

IF YOU GO

* WHAT: Avalanche Safety 101 lecture

* WHEN: 7 p.m. Wednesday

* WHERE: Portland REI, 1798 Jantzen Beach Center

* COST: Free

* CONTACT: 360-693-0209

Mt Baker Fatality Article

HeraldNet

Mt. Baker avalanche claims life of Everett snowmobiler

Herald staff and news services

BELLINGHAM -- Authorities on Thursday identified a snowmobiler killed in an avalanche on Mount Baker as Jeff Diedrich, 31, of Everett.

Rescue workers pulled Diedrich out from under the snow and airlifted him to St. Joseph Hospital in Bellingham. He had been buried more than six hours.

Hospital officials refused comment Wednesday night on his condition.

Three other snowmobilers from the Everett and Marysville area who were with Diedrich reported about 10:30 a.m. Wednesday that he was buried in an avalanche in the Schreiber Meadow area on the south side of the mountain, around Squak Glacier.

The Whatcom County Sheriff's Office and local search-and-rescue volunteers responded.

Lake Ann Fatality Article

DAILY RECORD ONLINE
Kittitas County's Community Newspaper

Man killed in avalanche near Lake Ann area

Second snowmobile fatality of the winter 02/19/01
ANDREA PASCOE

CLE ELUM — An Ellensburg man was killed Saturday in a freak avalanche while snowmobiling in the Lake Ann area, approximately eight miles northeast of Salmon La Sac.

Mark Kastning, 35, was killed almost instantly when a slab avalanche caught him off guard as he traversed a hillside, Kittitas County Undersheriff Rob DeGroot said.

"On Saturday at approximately 4:30 p.m., deputies from the Kittitas County Sheriff's Office responded to the Lake Ann area on a report that an avalanche had trapped a snowmobile rider," DeGroot said. "It was later determined that the victim and 12 others had been riding snowmobiles in the North Fork Teanaway area and had just crossed over into the Lake Ann area."

DeGroot said Kastning and others were riding on a hillside when a slab avalanche, approximately 200 feet in width, broke loose and swept Kastning more than 300 yards downhill.

"These guys were all very good riders and knew the area well," Sgt. Fred Slyfield said. "They said they had never seen a slide in that area before, and neither have I. It just happened."

DeGroot said none in the party actually witnessed the incident; however, one alert rider noticed some debris and stopped to investigate.

"Two others (riders) who had been behind the victim arrived in the area and noticed a partially buried hood of a snowmobile. Upon further investigation, the riders found the victim's helmet which showed indications of having impacted an object with great

force. The snowmobile was located against a tree. It, too, had significant damage."

As one rider left the area with two cellular phones, others in the party began a search. Using four avalanche probes the group had brought in with them, the riders concentrated their efforts in and around the debris that had been scattered over a wide area. Kastning's body was discovered further down the hillside, DeGroot said.

"Kittitas County Search and Rescue personnel were advised that Kastning's body had been located," DeGroot said."Because weather conditions were rapidly worsening with heavy winds and near white-out conditions, body recovery was postponed until the following morning so as not to endanger any additional personnel. Others in the party returned from the area without further incident."

Members of Kittitas County Search and Rescue and Cascade Search and Rescue went in the following morning to retrieve Kastning and transport him to Steward and Williams Funeral Home.

"This is something that just happened," Slyfield said. "These guys were some of the best riders in Ellensburg and knew the area they were in very well. They had the right equipment with them and did the best they could. This was an unfortunate, tragic accident."

This is the second snowmobiling fatality this year. The Sheriff's Office advises winter sports enthusiasts that a high avalanche danger exists throughout the Upper County region. Those wanting current conditions may contact the U. S. Forest Service or the Northwest Weather and Avalanche Center at www.nwac.noaa.gov.

Twin Lakes Snowshoer Fatality Article

Searchers Find Snowshoer's Body: E. Wenatchee Man Killed In Avalanche

By Rick Steigmeyer, World staff writer

LAKE WENATCHEE - Search teams today found the body of an East Wenatchee man buried in an avalanche.

Chelan County Sheriff Mike Brickert said that Derek "Jay" Bowen's body was found about 10:50 a.m. beneath 4 feet of snow at the avalanche site near Twin Lakes.

The 33-year-old East Wenatchee man was snowshoeing Monday through steep terrain about 6 miles northwest of Lake Wenatchee when he was hit by the avalanche.

Rescue operations were based out of a rustic log lodge at the Tall Timber Ranch, a Bible camp operated by the Presbyterian Church. During the two-day search, rescuers used two-way radios, computers and global positioning system equipment to track the efforts of search teams.

Tired, frustrated searchers returned to the base about 6 p.m. Tuesday night after a long day on snowshoes looking for any trace of Bowen or the dog that disappeared with him. Five of the 10 searchers were Whitworth College students who had just completed a three-week winter mountaineering class at the camp. The students were scheduled to leave the camp Tuesday, but most elected to stay and aid in the search.

The searchers continued their efforts in near darkness after Denali, an 8-year-old golden retriever trained in avalanche rescue, came up with the first clue. The dog, adept at locating human scent beneath the snow, keyed in on a spot where searchers dug up a ski pole, but nothing else. The ski pole belonged to Seneca Mott, Bowen's hiking partner.

Mott, 29, of Cashmere, survived the avalanche. Mott and Bowen were good friends who had worked together the previous year for Lifeline Ambulance. She was an EMT. He was a paramedic. Bowen had taken a job a year ago for Samaritan Hospital in Moses Lake, but the two stayed friends and shared a love for outdoor recreation. Monday they traveled up the White River Road to snowshoe with their dogs the three miles between Tall Timber Ranch and Twin Lakes.

They reached the lakes about 3 p.m. and were about half a mile back toward the trailhead when they were hit by the slide. Mott told reporters she was too emotional to talk about the incident Tuesday, although she was at the base camp with her husband, Carey, awaiting word from the searchers.

She told deputies she was carried down the mountain less than 100 feet, never lost sight of what was happening and ended up only partially buried in the snow. She was shaken, but not seriously injured, and was able to dig herself out. She found two of the

three dogs. She used a ski pole to probe the snow for Bowen, but found no sign of him or any of his equipment.

Mott described the avalanche as approximately 20 feet by 200 feet in size and about 4 feet deep.

Strong winds were picking up the snow and threatening to bring down more avalanches, Mott said. She decided the best thing to do was go for help. One dog left the mountain with her. The other dog, also Bowen's, refused to leave.

She reached the Tall Timber lodge about 6 p.m. Monday. The second dog came down from the mountain later that night.

A Chelan County sheriff's search and rescue deputy and an avalanche technician who volunteers on rescue missions were the first to arrive at the scene within the hour. But it was already dark and it was snowing. Rescue attempts would have to wait until dawn.

Chelan County Undersheriff Doug Tangen sent out one five-member search team Tuesday morning, and another Tuesday afternoon after he determined that conditions were safe. By then, more slides had destroyed all clues and added to the snow depth, he said.

The snow is not particularly deep for this time of year, maybe 2 feet, said Sheriff's Capt. Pete Peterson. But there is extreme avalanche danger, because of layers of snow on top of layers of ice. Temperatures were expected to remain near freezing today with threat of additional avalanches. A new weather system was forecast to bring more severe weather and more snow by Friday.

Greg Moser, Bowen's supervisor at Samaritan Hospital and a close friend, said Bowen knew as much as anyone he had ever met about outdoor survival. Moser said Bowen had moved to Washington from Mississippi about three years ago. He had no relatives here and was not married.

John Garavelli, Bowen's uncle in Washington, D.C., said his nephew was adventuresome, easy to get along with and in love with nature, the outdoors and the environment.

NWAC Annual Operating Schedule by Period—2000/01

TIME	STAFF	WORK
1 SEPT-15 SEPT	1	Instrumentation and Office Inventory; Prepare equipment orders; Outline changes and impacts in new Weather Service or other cooperator programs; Begin programming computers for any changes; Check status and begin to prepare computer systems for operational forecasting; Work with equipment engineers/manufactures on equipment modifications to enhance reliability
15 SEPT-31 OCT	3	Check over/repair stored field equipment; Order replacement or new sensors as needed; Order office equipment as needed; Begin to troubleshoot & repair field data network; Prepare office for forecasting; Work on computer programming & get data/forecast archival programs ready; Prepare field observer network and train cooperators as needed; Prepare office communications; recorders, & web site; Prepare/revise avalanche/weather education talks and begin avalanche education efforts and awareness programs
31 OCT-15 NOV	3	Finish data network repair and installation; Program remote sites and check output; Ensure all data is on-line; Begin weather and avalanche forecasting for highways and seasonal pass closures; Attend National Avalanche School or Snow Science Workshop; Continue avalanche awareness programs
15 NOV-15 APRIL	3.1	Operational daily mountain weather and avalanche forecasting; Respond to news media requests for information; Provide avalanche and mountain weather education programs; Repair data network as necessary; Analyze snowpack; Investigate avalanche accidents and prepare reports; Assist highways, ski areas, Park Service in avalanche control needs; Assist SAR operations as needed; Archive data and respond to special data/forecast requests; Update web site; Keep all weather/avalanche/snowpack logs up to date
15 APRIL-31 MAY	3	Prepare highway forecasts for reopening of seasonal passes; Monitor weather and snowpack; Issue special avalanche statements as needed; Remove selected sensors/data sites and store for summer or provide for extended summer operation where possible; Analyze data network status for next year; Finish data archival for season and prepare seasonal statistics/charts/graphs; Plan for any major new/revised data sites; Analyze budget status; Prepare annual report for cooperators and for meeting; Seasonal assessment by forecasters
1 JUNE - 15 JUNE	3	Annual cooperator meeting--meet with cooperators to discuss past and future season problems and successes and determine/agree on funding levels; Continue preparation for next season; Determine needed changes for next season
15 JUNE-1 JULY	1	Continue planning for next season; Order needed field and office equipment; Begin computer programming changes for office and field; Install/repair field equipment as needed
TOTAL STAFFING	2 forecasters for 20 PP, 1 forecaster for 22 PP, 1 forecaster for ~1 PP; Total of 2.3 FTE's for the year	

Daily NWAC Schedule—Operational Forecasting

TIME	WORK
0300-0530	COFFEE OR TEA! Analyze weather data from field—fix computer or field stations as necessary; Analyze NWS data from forecast models, satellite and radar imagery, surface observations; Record and analyze snowpack and avalanche data from field observers; Consult with NWS forecasters on mountain conditions and forecasts; Log variety of weather data; check on operation of data network
0530-0700	Prepare morning mountain weather forecast; Log and analyze incoming data from field observers; Advise cooperators regards expected weather and avalanche conditions; Continually check on hourly info from data network; Disseminate weather forecast via NWS channels, web site, recordings
0700-0900	Continue to log and analyze incoming field data from observers; Prepare summary and detailed avalanche forecasts; Update mountain weather forecast if necessary; Disseminate avalanche forecast via NWS channels, web site, recordings
0900-1100	Continue to check on weather; Continue to receive new field data and advise cooperators; Record and archive weather and avalanche data; Ensure proper dissemination of all forecast and data information; Conduct program changes as needed to support data network; Check & answer email; Conduct administration or work on avalanche/weather education efforts and talks as needed; Update web site with new information
1100-1400	LUNCH!! Analyze weather data from field—fix computer or field stations as necessary; Analyze NWS data from forecast models, satellite and radar imagery, surface observations
1400-1500/1600	Prepare updated mountain weather forecast for afternoon dissemination and update avalanche forecast as necessary; Disseminate updated weather forecast; Ensure data network and web site/recordings are operating correctly; Call cooperators with updates as needed
15/1600-0200	Never does bed look so good—ZZZZZZZZZZZZZ!!

In general, 2-3 day operational forecast shifts are interspersed either with 1-2 day field trips for snowpack analysis and instrumentation, or with additional office and administrative work not completed during normal forecasting shift hours.