Northwest Weather and Avalanche Center

2006-2007 Annual Report

Report prepared by Mark Moore, Kenny Kramer and Garth Ferber

A partnership between the USDA Forest Service, Washington State Parks and Recreation Commission, National Park Service, National Weather Service, Pacific Northwest Ski Area Association, Washington State Department of Transportation, Washington State Snowpark and Snowmobile Programs, USDA Forest Service Fee Demo programs, Title II RAC programs, Ski Schools, Friends of the Avalanche Center and others.

United States Department of Agriculture

Forest Service Pacific Northwest Region

Cover Photo credits:
This photo of a snow roller (snow pinwheel, snow donut) was taken along the east slopes of the northern Washington Cascades in Mid-March of 2007 by Mike Stanford, Washington State Department of Transportation (WSDOT) avalanche control technician, during an avalanche control and reconnaissance mission on Washington Pass. While snow rollers are common occurrences during spring time warming in many mountainous regions, most rollers are observed as a solid wheel and often end up as wheel fragments as they break apart in the rolling process. A mature snow roller of this size without the inner middle is less common, especially totally intact like this one is. Most rollers like the one shown initially form through warming and melting of near surface snow. With surface warming, a small clump of snow may release from steeper terrain, warming rocks or snow laden tree boughs. With time the small unstable mass begins to roll and gather concentric rings of surface snow as it descends down slope. The rolling action may produce mechanical separation of the less dense middle (formed initially when compression of the snow is slight) from the more compact outer edges (formed with more compressive forces as the wheel increases in size), producing the snow donut pictured. These rollers are also an indication of snow stability, for if the near surface snow is not unstable enough to slide by the weight or pushing action of such rollers, the rollers may help to stabilize the snowpack by either carving up surface slabs, local densification of near surface snow, or through the production of minor sluffs.

TABLE OF CONTENTS

List of Figures

List of Tables

A MESSAGE FROM THE DIRECTOR *– Although the specter of an El Niño winter provided early season doubt and concern amongst many in the Northwest, professional and recreationist alike, the potential gloom and doom that occurred during some recent past events of weak to moderate El Niños (e.g., 1992/93 and 2004/05) was not to be. The season started robustly (see the comparison figures in the weather and snowpack section below and on the NWAC web site) in early-mid November and stayed mostly above or well above both climatology and a weak-moderate El Niño average for most stations for much of the winter. Although blocking ridges brought some trepidation in mid-January to mid-February when the abundant early season snows stopped for awhile, a cool and intermittently snowy mid-late February, March and early April assured a reasonable snowpack and relatively healthy water supply...at least at most mid and higher elevations and near and west of the Cascade crest. In retrospect, the winter of 2006/07 had a little bit of weather and related concerns for most everyone—high winds (Mission Ridge recorded sustained winds over 80 mph on several occasions with gusts reaching 110-120), heavy snowfalls to lower elevations, rapid warm-ups and plenty of avalanche danger. Although many avalanche incidents were reported in the Northwest, most of those involved were lucky with the primary impacts being confined to minor injuries or lost equipment—and details were sketchy on most of these. Unfortunately, one accident was much more serious and resulted in the only NW avalanche fatality through early May—the detailed report is available on the accidents page of the web site. Nationwide, the past season produced 20 fatalities through May 1 and 26 for North America (US and Canada).*

While seasonal web site access of NWAC products for 2006/07 was down slightly from the record setting winter of 2005/06, the ~3.5 million hits on data and forecast products is still quite robust and along with the low NW fatality total, these statistics provide a continuing indication of the importance of Avalanche Center information. Several new remote weather stations came on line this past year (Dirty Face and Lake Wenatchee along the Cascade east slopes and Camp Muir on Mt Rainier), with seasonal accesses of remote weather station data reaching over 2.7 million hits. Increased hourly weather information like these stations was complemented by expanded information from a new snow profile and photo page as well as an enhanced home page and additional links to recent papers, publications and other avalanche or mountain weather related articles.

The value of the Avalanche Center to Washington State and its residents was underscored by the initiation, development and relatively quick passage of an Avalanche Center Bill (SSB5219) through the Washington State Legislature, as well as its subsequent signing by Governor Gregoire. The bill seeks to establish long term and stable funding for the NWAC, i.e...."It is the intent of the legislature to ensure, in continued cooperation with federal and private sources, that the NWAC receives the resources necessary to continue providing weather and avalanche forecasts for the benefit of Washington State." Thanks to many interested parties, in particular to the FOAC (Friends of the Avalanche Center), the legislators, and the Governor, for their efforts in promoting and ultimately establishing such legislation. While it is only a start, it is a most positive step forward toward long term stable funding of the Northwest Weather and Avalanche Center.

Finally, on a more somber note, it is fitting that legislation to help ensure the long term viability of the Avalanche Center should occur very close to the passing of one of its prime creators, Dr. Ed LaChapelle. Long considered the "Father of Avalanche Science" in the US, Ed passed away this spring doing one of the things he loved most—skiing powder with friends. For so many of us in the avalanche profession, Ed was much larger than life and a mentor to many. His wise counsel, sharp wit and keen insights into snow and ice certainly gave our community of avalanche folks a purpose and meaning that extended well beyond the confines of universities and textbooks. In so many ways, Ed epitomized the life of the field researcher as he

*sought to simplify and unify theory and practice, giving many of us ideas or direction that helped shape our lives. He was engaged and engaging—a true avalanche wizard , and his presence on the slopes of snow and ice that he so often frequented will be sorely missed. Thanks from all of us, Ed—**Mark Moore, Director (May, 2007)***

NWAC MISSION STATEMENT

To reduce the impacts of adverse mountain weather and avalanches on recreation, industry and transportation in Washington and northern Oregon through data collection, forecasting and education. This promotion of public safety is accomplished by providing cooperating agencies and the public with:

- Mountain Weather Data
- Mountain Weather Forecasts
- Avalanche Forecasts
- Education
- Applied Research and Technology

How to get NWAC mountain weather and avalanche forecast information:
http://www.nwac.us
206-526-6677 (Seattle Hotline)
503-808-2400 (Portland Hotline)

How to reach us for other information:
Northwest Weather and Avalanche Center
7600 Sandpoint Way NE
Seattle, WA 98115
206-526-6164 (office); 206-526-4666 (messages)
nwac.sew@noaa.gov

OPERATIONS SUMMARY

Forecast staff at the NWAC are employed by the USDA-Forest Service from mid September to mid-June. The following is a summary of the main NWAC tasks during the 3 distinct parts of our season:

Fall Season (mid September to mid November):

- Plan for upcoming season.
- Attend and provide input and instruction at the International Snow Science Workshop (ISSW) or National Avalanche School (NAS).
- Office preparation especially of forecasting and weather station computers.
- Weather station installation, upgrades and repairs.
- Preliminary mountain weather forecasting for ski areas, WSDOT.

Winter Season (mid November to mid April):

- Provide daily mountain weather and avalanche consultations to ski areas, WSDOT crews and other cooperating agencies, starting at 3:30 am, 7 days a week.
- Prepare and disseminate twice daily public mountain weather forecasts (7 am) and daily avalanche forecasts (9 am) 7 days a week; provide updates and special statements as necessary.
- NWAC weather station repairs; ensure high quality data via the NWAC web site.
- Gather snow pack information first hand and from others; integrate into avalanche forecasts.
- Provide avalanche awareness presentations as requested.
- Prepare and update web site pages with accident and snowpack statistics, and educational information.

Spring Season (mid April to mid June):

- Continue to provide mountain weather and avalanche consultations to cooperating agencies, such as WSDOT crews at Washington and Chinook passes.
- Issue special avalanche statements when necessary.
- NWAC weather station upgrades or repairs; continue to provide quality data via the NWAC web site.
- Prepare for annual meeting and issue annual report.
- Plan operations for next season.

INFORMATION EXCHANGE

Incoming Information:

Through the winter NWAC forecasters rely on incoming information and data to make accurate assessments of current mountain weather and avalanche observations. This information comes from the following sources:

- **Observer Network**: The forecaster at the NWAC receives daily weather and avalanche observations via telephone from most ski areas, WSDOT crews, and observers at Hurricane Ridge and Paradise on Mt Rainier.
- **Backcountry Observations**: The NWAC makes as much use as possible of available back country snow and avalanche observations via phone calls and e-mail messages, the FOAC Snowpack Information Exchange, and sources on the Internet such as the Turns-All-Year.com.
- **NWAC Weather Stations:** The NWAC currently maintains or helps maintain 42 weather stations located at NPS, WSDOT and ski area sites at Hurricane Ridge in the Olympics and in many locations throughout the Cascade Mountains. These stations provide temperature, relative humidity, wind, precipitation and snowfall information automatically via phone and radio connections.
- **National Weather Service:** NWAC staff has access to all products and expertise of the National Weather Service Seattle office.

Outgoing Information:

The NWAC distributes mountain weather and avalanche information via the following means:

- **Phone Consultations**: at least once daily with most ski areas, DOT crews at Stevens and Snoqualmie Passes, and observers at Paradise, Mt Rainier National Park. Consultations increase to multiple times/day during periods of rapidly changing weather and avalanche conditions.
- **Public Hotline Phone Recordings**: in Seattle and Portland. Overall the number of calls to the recorders has decreased as the use of Internet access has skyrocketed (Figure 2); however overall for both the Portland and Seattle hot lines, the annual total still averages about 5-7,000/year.
- **Internet**: Visitors and unique visits to the NWAC web site have greatly increased over the past few seasons, as indicated below in Figures 3 and 4. See Figure 1 for a weekly access breakdown and Figure 2 for an annual tally of product hits that is now averaging between 3.5 and 4.5 million/year. On average, the NWAC web site receives about 21,000 hits/week on forecast products (with a weekly maximum of ~34,000 accesses/week), and around 110,000 hits/week on data and forecasts (weekly maximum of over 200,000 hits/week). Note that these figures still represent the "tip of the usage iceberg", as a variety of other web sites download data and forecasts and either make them locally available on other servers or provide an email product for subscribers. Thus, while Figure 2 below shows a slight decrease in overall number of hits on NWAC products for the past year as compared to the record setting season of 2005/06, Figures 3 and 4 show a significant increase in unique visitors to the site during this past year.
- **NOAA Seattle Weatherwire**: NWAC products are also distributed to the media and commercial vendors via the Weatherwire service. To help increase danger awareness of "avalanche warning" situations (high or greater danger at or below 4000 feet in the Washington Cascades or Olympics and 5000 feet in the Mt Hood area), NWAC forecasters also collaborated with the National Weather Service to add an "Avalanche Section" to the highly popular NWS Area Forecast Discussion (AFD) product. An example of this product is shown below with the avalanche portion highlighted:

```
ZCZC SEAAFDSEW
FXUS66 KSEW 241631
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE SEATTLE WA
830 AM PST SAT FEB 24 2007

.SYNOPSIS...A VIGOROUS FRONTAL SYSTEM WILL SWEEP THROUGH WESTERN WASHINGTON TODAY. A
COLD UPPER LEVEL TROUGH WILL REMAIN IN THE NORTHEAST PACIFIC INTO THE FIRST PART OF
NEXT WEEK...FOR COOL SHOWERY AND AT TIMES BLUSTERY WEATHER.

&&

.SHORT TERM...SNOW TURNED TO RAIN IN THE BREMERTON AREA ABOUT AN HOUR AGO ACCORDING TO
AN NWS EMPLOYEE...AND NOW KSHN IS REPORTING RAIN INSTEAD OF SNOW. NOT SURE WHAT THE
AMOUNTS WERE ALONG HOOD CANAL BUT JUDGING FROM THE ASOS AT SHELTON COULD HAVE BEEN 3-4
INCHES. THIS SHOULD MELT TODAY AS PCPN TURNS TO RAIN AND WINDS TURN SOUTH AND SLOWLY
WARM THINGS UP.

DIFFICULT TO PIN DOWN ANY SORT OF FRONTAL FEATURE ON SATELLITE IMAGERY BUT JUST
LOOKING AT OBS...IT APPEARS SOME WARMER AIR HAS MADE IT INTO THE SOUTHERN SUBURBS OF
PORTLAND OREGON. THIS WOULD PUT A WARM FRONT THROUGH SEATTLE SOME TIME THIS
AFTERNOON...WHICH SEEMS MORE OR LESS IN TUNE WITH THE FORECAST. EXPECT RAIN AT TIMES
UNTIL THEN...SHOWERS AFTERWARD. THE MOUNTAINS WILL CONTINUE TO GET SNOW ALL DAY AND
WILL KEEP SNOW ADVISORY GOING.
```

SHOWERS WILL REMAIN IN THE FORECAST TO VARYING DEGREES THROUGH MONDAY AND INDEED MOST OF NEXT WEEK. BURKE

.LONG TERM...PREVIOUS DISCUSSION...A COLD AND SHOWERY PATTERN CONTINUES INTO THE MIDDLE OF NEXT WEEK. WILL MAINTAIN THE CURRENT BROAD BRUSH FORECAST WITH HIGHER POPS IN THE MOUNTAINS. TEMPS MAY MODIFY A LITTLE BY THU AS THE LARGE SCALE TROUGH ALONG THE W COAST SHIFTS FURTHER EWD...GIVING RISING HEIGHTS OVER THE AREA. STILL A CHANCE OF RAIN THOUGH WITH THE MAIN STORM TRACK NEAR OR JUST N OF THE AREA. MERCER

&&

.AVIATION...A WARM FRONT WILL GRADUALLY PUSH INLAND TODAY...PASSING SEA-TAC LATER THIS AFTERNOON. AREAS OF SNOW AND MIXED RAIN AND SNOW THIS MORNING WILL GRADUALLY MIX OUT AS WARM FRONT MOVES INLAND. MVFR CIGS AND VSBY IN PRECIPITATION WILL REMAIN AN ISSUE THROUGH MOST OF THE DAY. WIND ON FINAL APPROACH TO SEA-TAC COULD BE AN ISSUE WITH S-SW WINDS AROUND 020-050 OF 35-45 KTS ON THE KUIL 12Z SOUNDING THIS MORNING...AND EXPECTED THROUGH AT LEAST MID-DAY. A QUIETER PERIOD IS EXPECTED BY LATE AFTERNOON OR EARLY EVENING AS THE WARM FRONT MOVES TO THE EAST AND WINDS AND WEATHER START TO EASE. THE AIR MASS WILL REMAIN MOIST THIS EVENING...BUT WEAK SUBSIDENCE SHOULD BEGIN TO TAKE HOLD AFTER 00Z WHICH SHOULD START THIN OUT SOME OF THE CLOUDINESS. PRANGE

.AVALANCHE...PLENTY OF LOW DENSITY SNOW RECEIVED DURING PAST FEW DAYS ALONG WITH SEVERAL BURIED WEAK LAYERS SHOULD BE LOADED AND STRESSED BY INCREASINGLY DENSE AND SLIGHTLY WARMER WIND DRIVEN SNOWFALL SATURDAY MORNING AND MID-DAY BEFORE FRONT MOVES EAST OF CASCADES BY MID-LATE AFTERNOON. AS THIS SHOULD PRODUCE AN INCREASINGLY SENSITIVE SNOWPACK WITH UNSTABLE WIND SLABS LIKELY ABOVE ABOUT 4000 FEET AND PROBABLE BELOW, WILL ISSUE AVALANCHE WARNING TO HIGHLIGHT SUBSTANTIAL INCREASE IN THE AVALANCHE DANGER. WITH MORE SNOWFALL ACCOMPANYING ANOTHER, THOUGH WEAKER, SYSTEM SUNDAY, EXPECT ONLY A LIMITED DECREASE IN THE DANGER THROUGH THE WEEKEND. HOPE THAT BACK COUNTRY TRAVELERS WILL HEED OR RECOGNIZE THE DANGER INCREASE AND TRAVEL ON MORE GENTLE TERRAIN FOR AWHILE. FOR DETAILS SEE WWW.NWAC.US. MOORE

THIS SECTION IS PROVIDED IN PARTNERSHIP WITH THE USDA FOREST SERVICE NW WEATHER AND AVALANCHE CENTER.

&&

.SEW WATCHES/WARNINGS/ADVISORIES...
...GALE WARNING FOR THE COAST...WEST ENTRANCE...EAST ENTRANCE...
ADMIRALTY INLET...AND THE NORTHERN INLAND WATERS...
...SMALL CRAFT ADVISORY CENTRAL STRAIT...PUGET SOUND AND HOOD
CANAL
...SMALL CRAFT ADVISORY FOR ROUGH BAR CONDITIONS GRAYS
HARBOR BAR...

$$

WEATHER.GOV/SEATTLE

NNNN

- **Search and Rescue Assistance:** The NWAC provides weather and avalanche forecast assistance to County Search and Rescue teams as necessary.
- **NWAC mountain weather station data:** Data for the past 17 years is available upon request.

Figure 1. Weekly forecast and data access on NWAC web site.

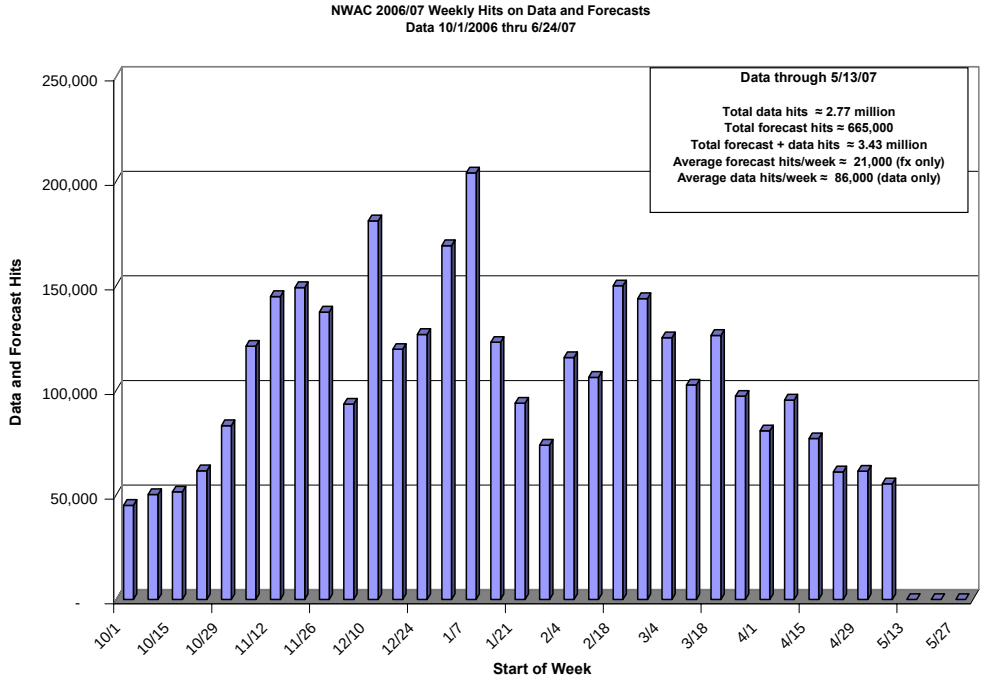


Figure 2. NWAC data and forecast dissemination over the past 13 years.

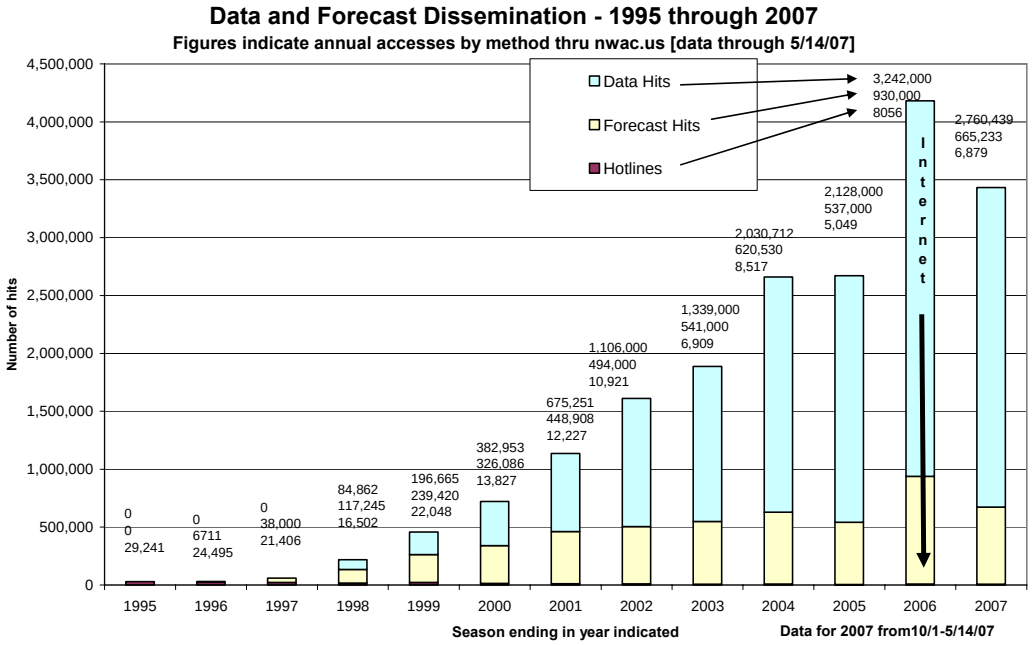


Figure 3. Annual plot of unique visitors to NWAC web site by week, 2004-2007

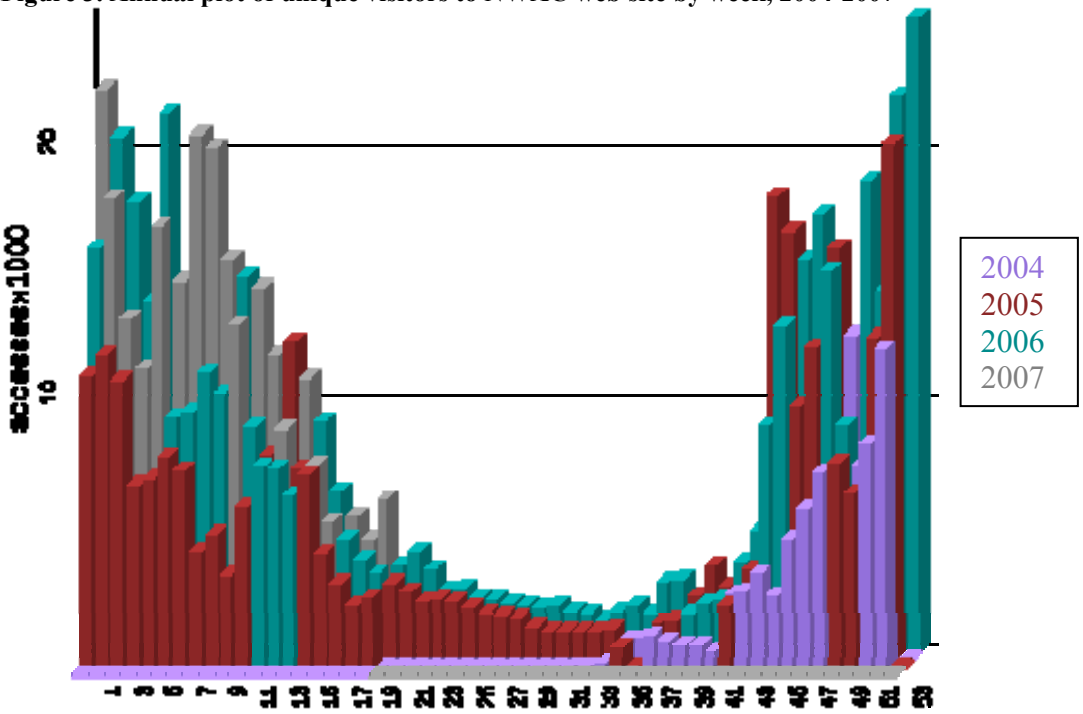
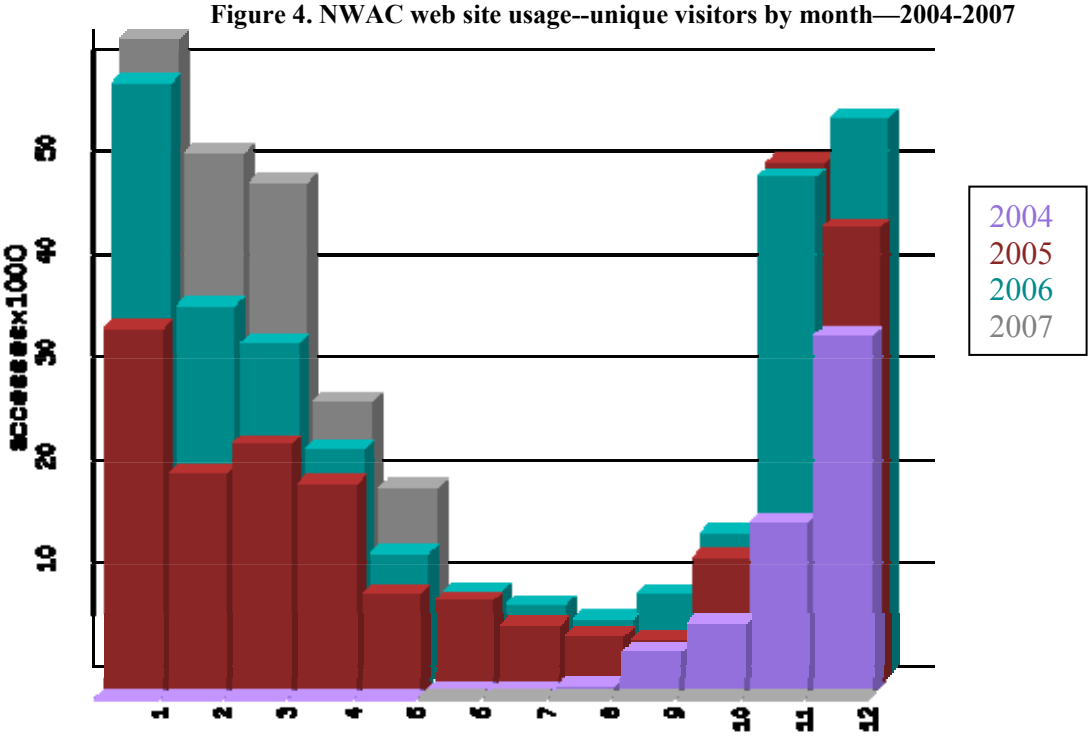


Figure 4. NWAC web site usage--unique visitors by month—2004-2007



2006-2007 EL NIÑO

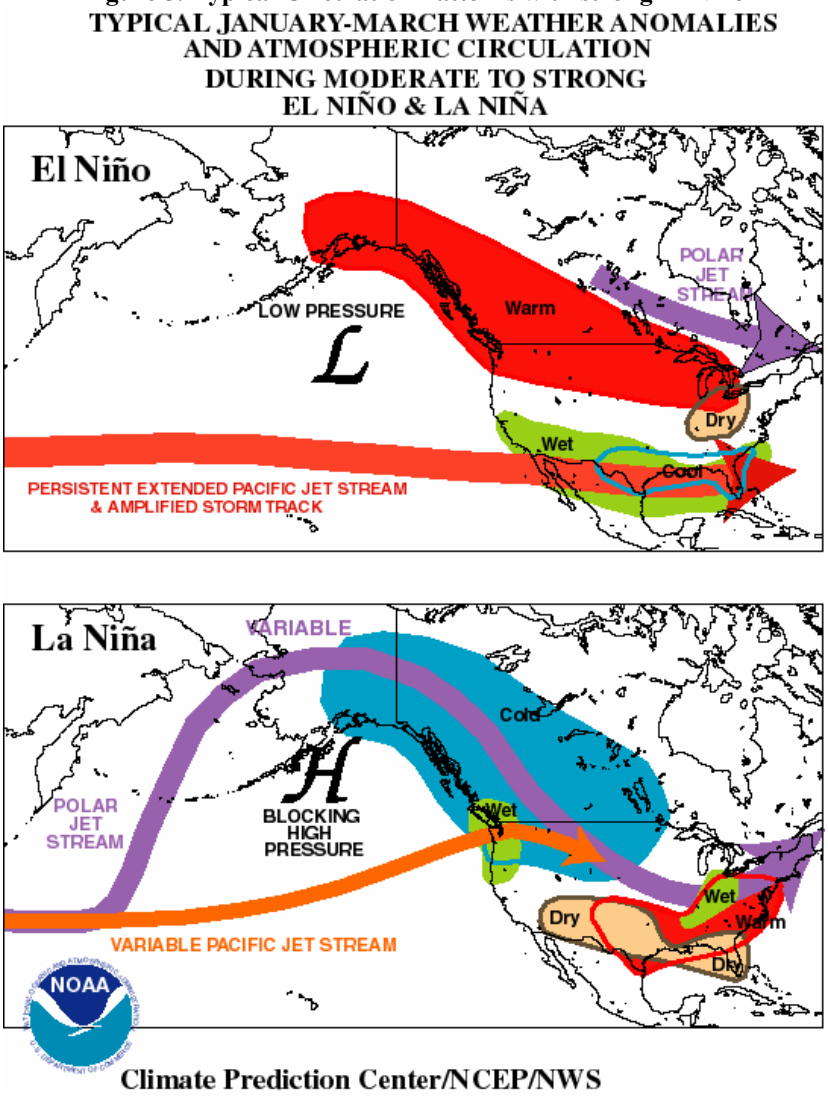
After indicating development of a weak El Niño (warm event) late last spring into early summer, late fall analyses and forecasts by the National Center for Environmental Prediction (NCEP—http://www.cpc.ncep.noaa.gov/products) indicated that this event could evolve into a moderate El Niño over the fall and winter of 2006/07. And this is pretty much what happened during the late fall and winter of 2006/07.

So what is El Niño and what sort of atmospheric circulation results from a moderate to strong El Niño in a typical Northwest winter? El Niño is normally defined as "an irregularly recurring flow of unusually warm surface waters from the Pacific Ocean toward and along the western coast of South America that prevents upwelling of nutrient-rich cold deep water and that disrupts typical regional and global weather patterns". NCEP describes its primary effects on North America as:

> *"El Niño episodes are associated with four prominent changes in the wintertime atmospheric flow across the eastern North Pacific and North America. The first is an eastward extension and equatorward shift of the East Asian jet stream from the International Date Line to the southwestern United States. The second is a more west-to-east flow of jet stream winds than normal across the United States. The third is a southward shift of the storm track from the northern to the southern part of the United States. The fourth is a southward and eastward shift of the main region of cyclone formation to just west of California. This shift results in an exceptionally stormy winter and increased precipitation across California and the southern U.S, and less stormy conditions across the northern part of the country. Also, there is an enhanced flow of marine air into western North America, along with a reduced northerly flow of cold air from Canada to the United States. These conditions result in a milder than normal winter across the northern states and western Canada."*

While this description of drying and warming in the Pacific Northwest brings tears and fears to much of the back country snow community, we must not lose sight of the fact that these are, after all, only statistics, statistics that skew the odds slightly in favor of such an outcome. Indeed, the Northwest has had reasonably robust winters during prior moderate El Niño events (see the graphs below). During the El Niño of 1994/95 most NW mountain sites reported above to much above average early season snowfall and snowpacks in November into mid January. Stevens Pass reported a 22 inch snowfall on November 1, 1994 and most sites near and west of the crest reported 30-40 inches of snow on the ground a few days later! While this may not be the norm during El Niño, it indicates that outstanding snow possibilities can and do still occur during these "warm" events. For a great site by site analysis of specific NW mountain stations during both El Niño and La Niña winters, please consult Amar Andalkar's web site at http://www.skimountaineer.com and navigate to the pages on historical snowdepth data. But now let's get back to the upper level flows that are more typical during an El Niño. The following graphic shows a generalized winter jetstream in North America and indicates the associated precipitation and/or temperature pattern that is often the result (as well as that for its colder sibling, La Niña). Unfortunately but not exclusively, statistics do favor a slightly warmer and slightly drier than average winter for our region.

Figure 5. Typical Circulation Patterns with strong El Niño



The global influence of such a moderate El Niño event is shown below. At this point in our study of wide reaching weather effects, we should just be happy that we're not in the boomerang shaped very dry area to the northwest of Australia.

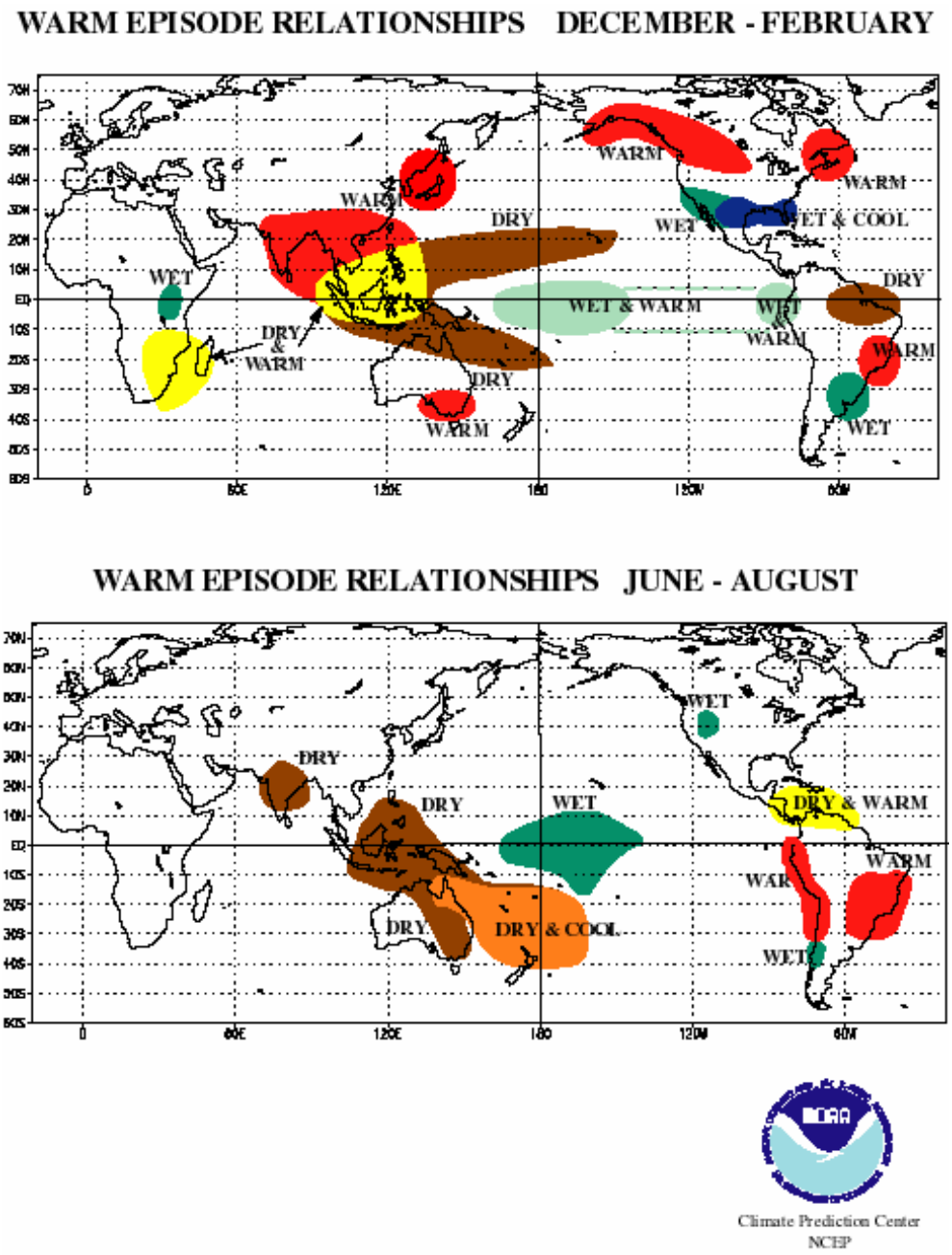


Figure 6. Warm episode relationships by season

And how often does an El Niño occur, you might wonder? To answer this it must be noted that El Niño and La Niña events are often classified by a number of different criteria. Some classification systems use the strength and sign of the Southern Oscillation Index (SOI), while others use Sea Surface Temperature (SST) anomalies for a variety of Pacific regions. Still others use a combination of several criteria to gauge the type and strength of the event. Consequently there are number of different lists which are actively used. Four of the most widely used lists are:

- Western Region Climate Center at http://www.wrcc.dri.edu/enso/ensodef.html
- Climate Diagnostics Center at http://www.cdc.noaa.gov/ENSO

- Climate Prediction Center at http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml
- Multivariate ENSO Index from Climate Diagnostics Center at: http://www.cdc.noaa.gov/ENSO/enso.mei_index.html

In the web site http://ggweather.com/enso/years.htm an event consensus was arrived at by choosing years which appeared on three of the four above lists. In this list, there is obviously some crossover of the variables used in the various methodologies and no attempt has been made to give a weight of one list over another. When WRCC, CPC and MEI all indicated W+ and CDC gave a W (their strongest category) then that season was considered a strong event. Otherwise the strength was determined from the "average" of the strength of chosen events. The resultant data is expressed in Table 1 (below), where W- = weak El Niño, W = Moderate El Niño, W+ = strong El Niño, and similarly with cold events (La Niña).

Table 1. Consensus List of El Niño and La Niña Years

Winter	WRCC	CDC	CPC	MEI	Consensus
1950-51	C+	C	C	C	La Niña
1951-52	W+		W-		
1952-53					
1953-54	W		W-		
1954-55			C	C-	
1955-56	C+		C+	C	Strong La Niña
1956-57	C		C-	C-	Weak La Niña
1957-58	W	W	W+	W	El Niño (moderate)
1958-59			W+	W-	
1959-60					
1960-61					
1961-62				C-	
1962-63				C-	
1963-64	W		W-		
1964-65	C		C	C-	La Niña
1965-66	W+	W	W	W	El Niño (moderate)
1966-67				C-	
1967-68				C-	
1968-69			W	W-	
1969-70	W		W		
1970-71	C		C	C	La Niña
1971-72	C		C-	C-	Weak La Niña
1972-73	W+	W	W+	W	Strong El Niño
1973-74	C+	C	C+	C+	Strong La Niña
1974-75	C		C-	C-	Weak La Niña
1975-76	C+	C	C+	C	Strong La Niña
1976-77	W		W-		
1977-78	W+		W-	W-	El Niño (weak to moderate)
1978-79					
1979-80			W-	W-	

1980-81					
1981-82					
1982-83	W+	W	W+	W+	Strong El Niño
1983-84			C-		
1984-85			C-	C-	
1985-86					
1986-87			W	W	
1987-88	W+	W-	W	W-	El Niño (moderate)
1988-89	C+	C-	C+	C	Strong La Niña
1989-90					
1990-91			W+		
1991-92	W	W	W+	W+	Strong El Niño
1992-93	W		W+	W-	El Niño (moderate)
1993-94	W+		W		
1994-95	W+		W	W-	El Niño (moderate)
1995-96			C-	C-	
1996-97					
1997-98	W+	W	W+	W+	Strong El Niño
1998-99	C+		C	C-	La Niña
1999-00			C	C	
2000-01	C	C	C-	C-	La Niña
2001-02					
2002-03	W	W	W	W	El Niño (moderate)
2003-04					
2004-05	W	W	W-	W/W-	El Niño (weak to moderate)
2005-06					
2006-07	W	NA	NA	W/W-	El Niño (weak to moderate+?)

How do the moderate or weak to moderate El Niño winters of the past 20-30 years stack up against overall climatology for some key NW mountain sites? For informational purposes the plots of representative sites in the NW are shown below from north to south: Mt Baker, Stevens Pass, Mission Ridge, Snoqualmie Pass, Crystal Mt, Paradise (Mt Rainier), White Pass, and Mt Hood Meadows. As previously mentioned, these graphs indicate overall lower snowdepths than normal during most but not all recent weak to moderate El Niño years.

Figure 7. Mt Baker snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

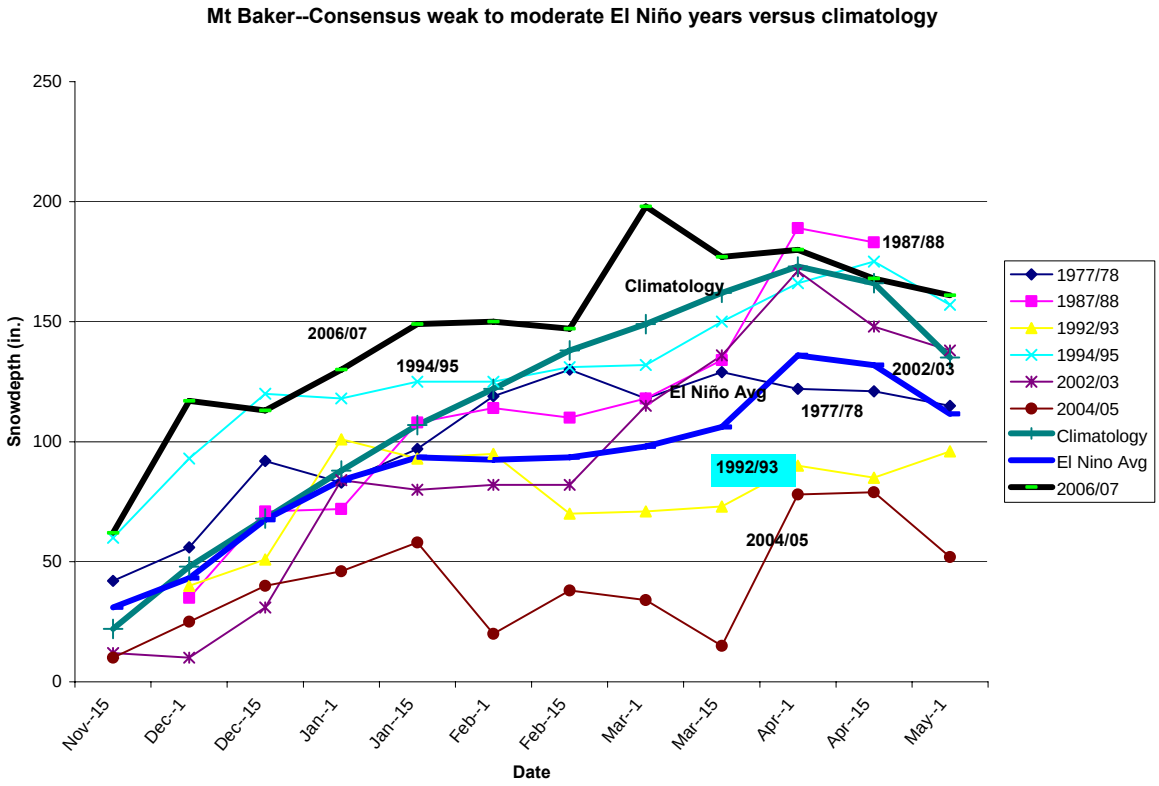


Figure 8. Stevens Pass snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

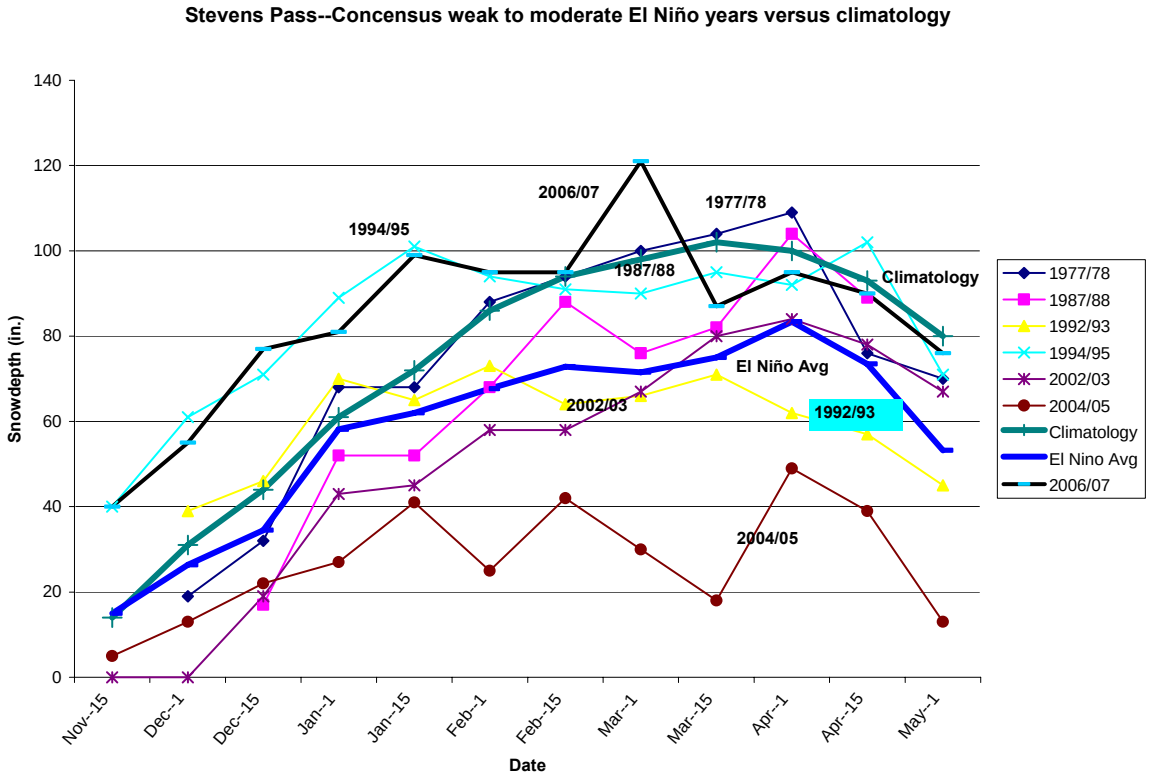


Figure 9. Mission Ridge snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

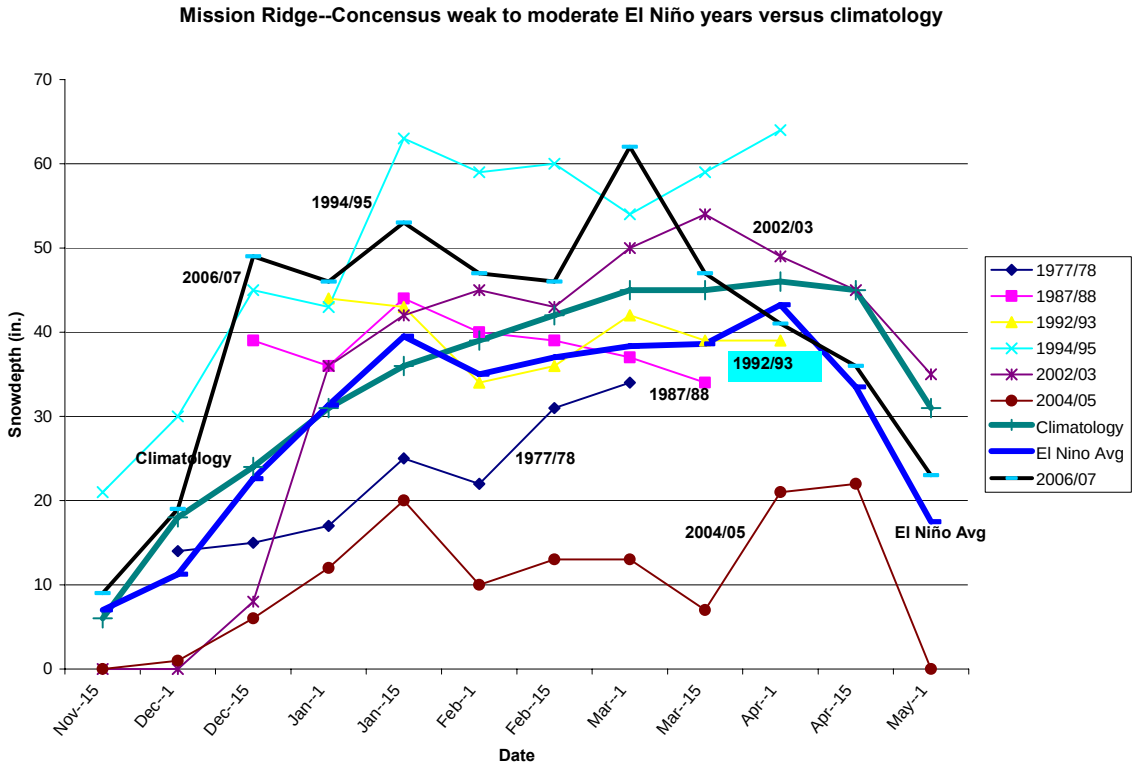


Figure 10. Snoqualmie Pass snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

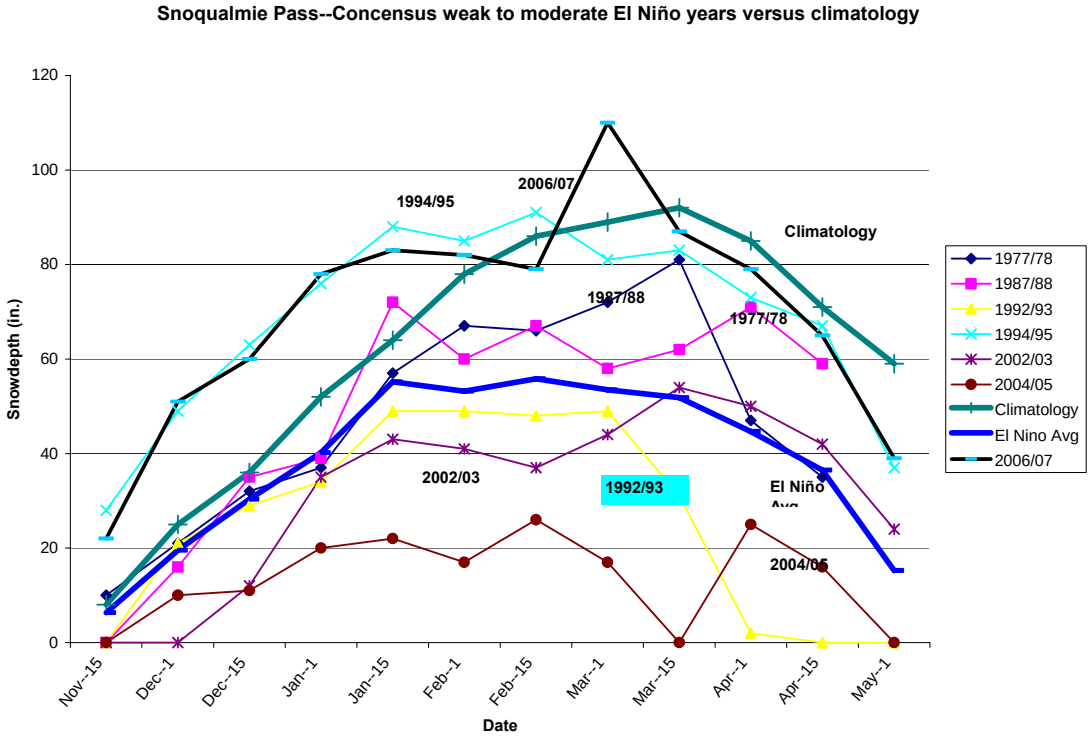


Figure 11. Crystal Mtn snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

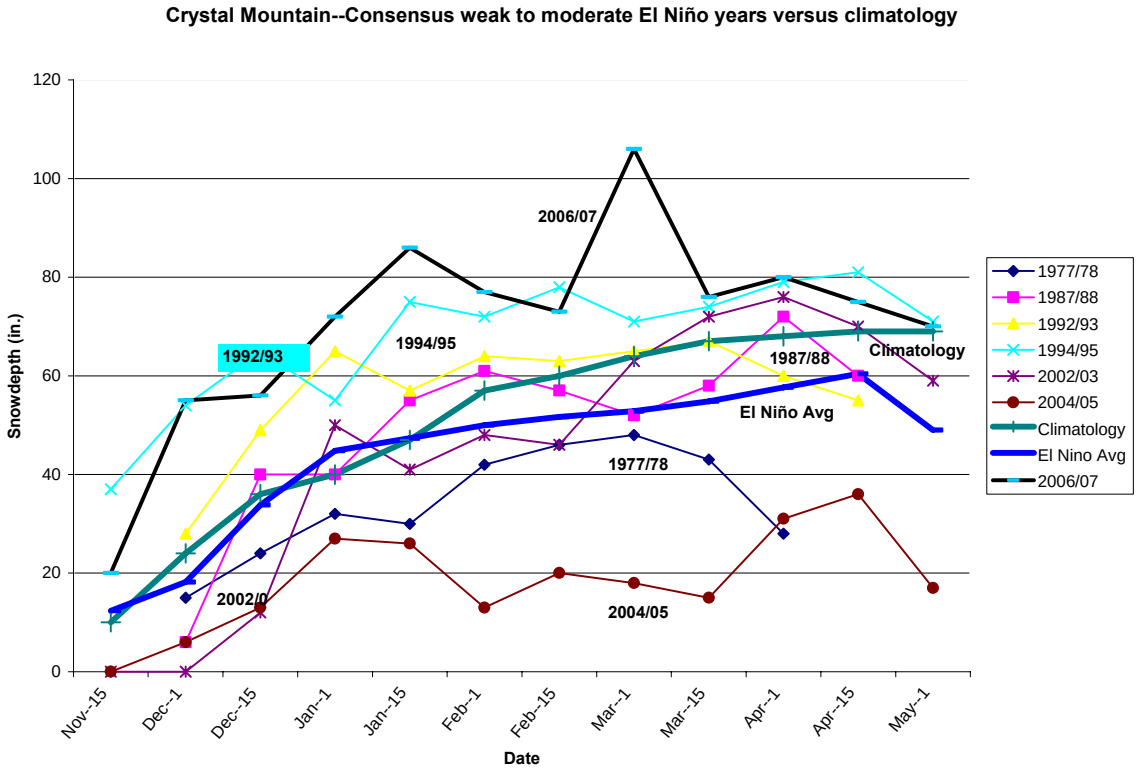


Figure 12. Paradise snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

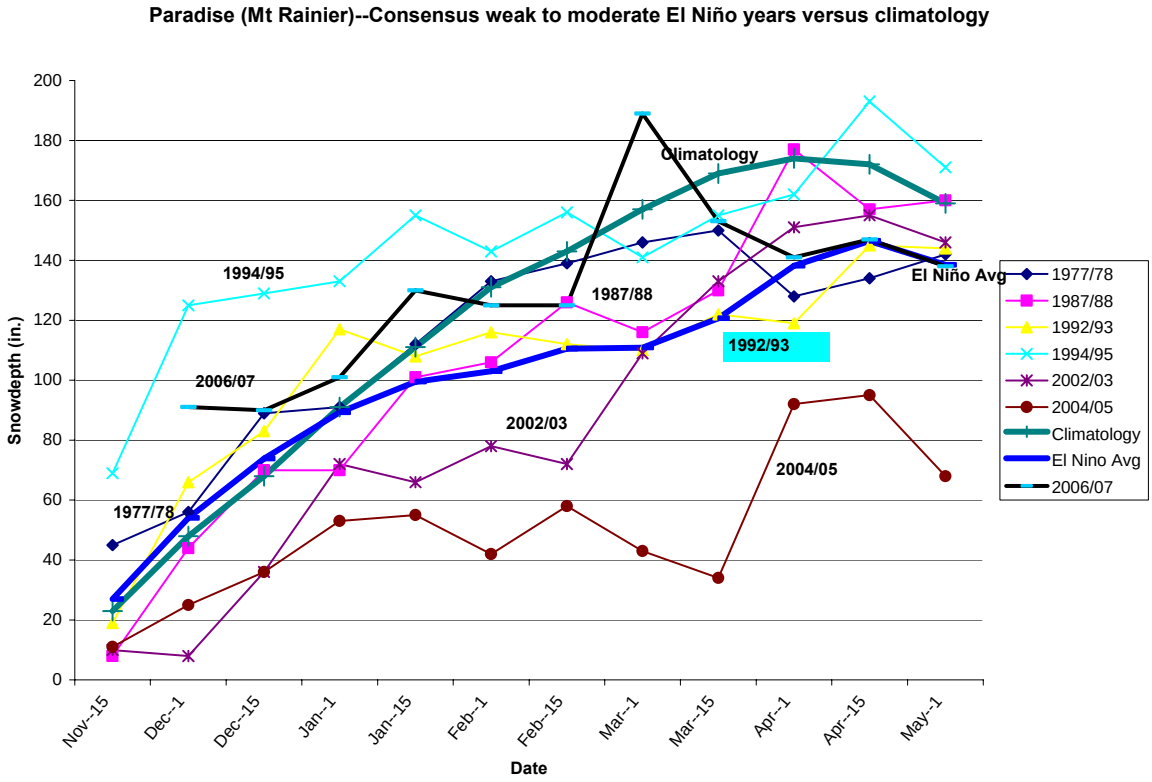


Figure 13. White Pass snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

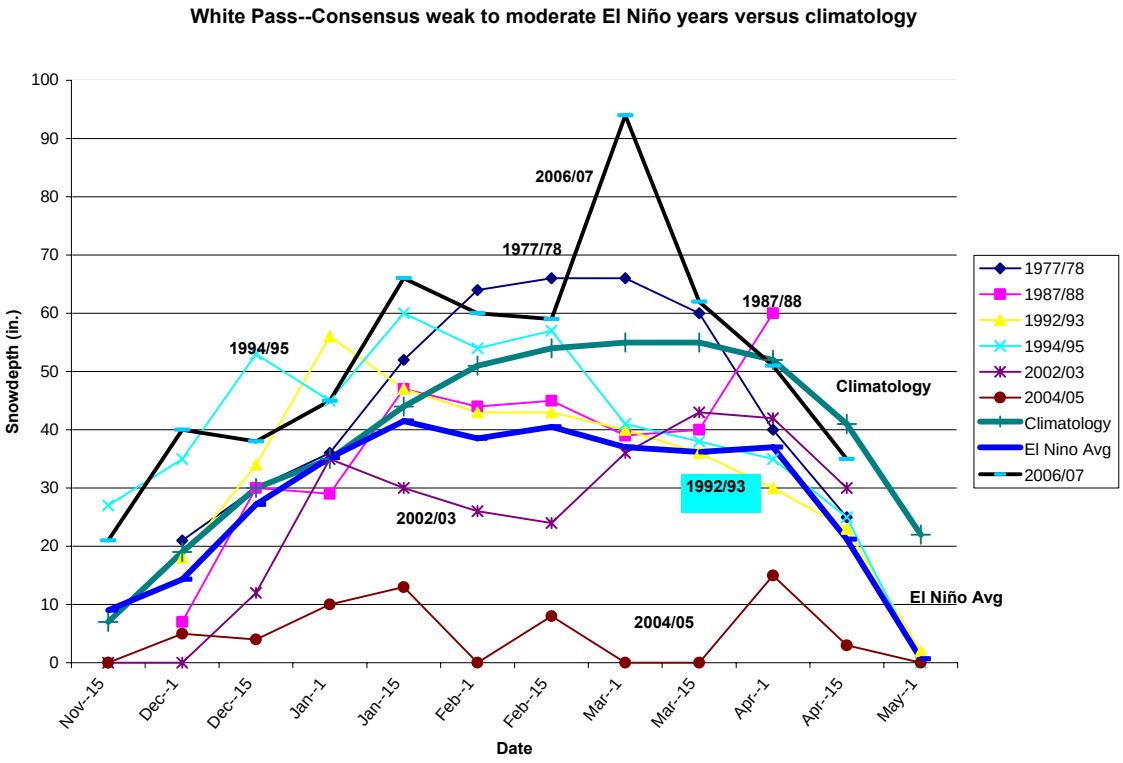
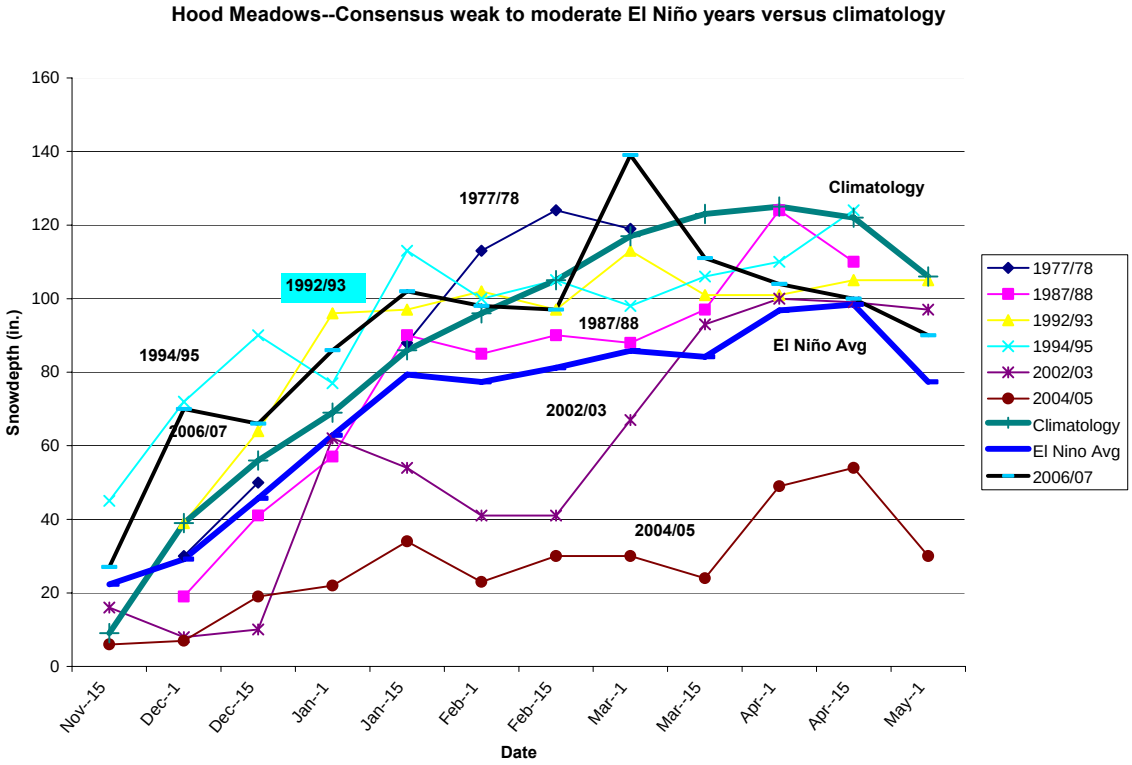


Figure 14. Mt Hood Meadows snowdepths vs climatology and El Niño avg--weak to moderate El Niño years

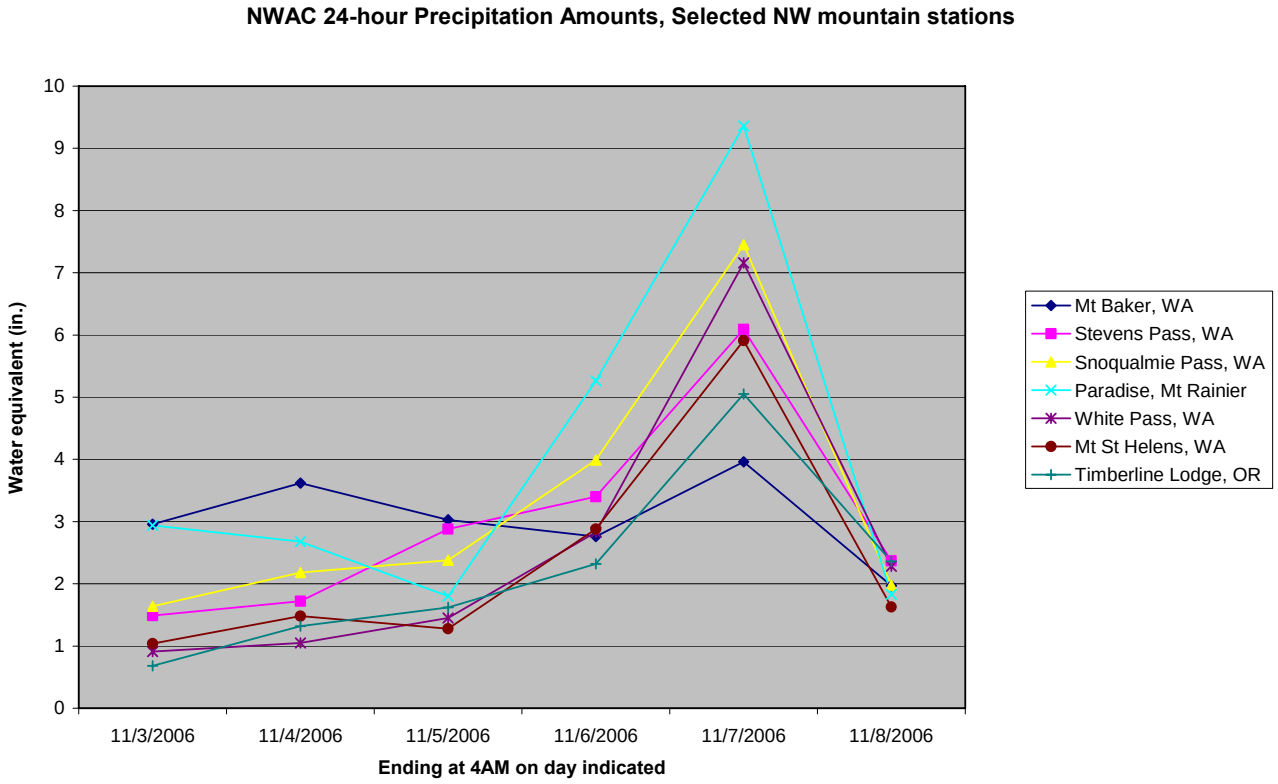


Obviously the charts above indicate that potential snowfalls for a weak to moderate El Niño winter may fall a little short of the norm. However, some reasonable years are indicated as well and the past El Niño winter was thankfully one of those.

The most recent El Niño discussion issued by NCEP indicates that the effects of this season's El Niño have pretty much waned or become Eñso-neutral, with a increasing chance for weak La Niña-like conditions evolving during the late spring and summer of 2007. How this will play out for next winter is at this moment unknown. No doubt it will be interesting when combined with all of the other climate oscillations that occur on a regular or intermittent basis.

2006-2007 WEATHER AND AVALANCHE SUMMARY

With a moderate and strengthening El Nino brewing in the Pacific, the season began under the uneasy feelings of a possible dour snow year unfolding in the region. Well, regardless of the conditions in the Pacific, the weather encountered in the Pacific Northwest was anything but uninteresting and most of the time truly dramatic! It began with the record flooding in early November when the NWAC precipitation gage at Paradise on Mt Rainier recorded over 14 inches in a 36 hour period and nearly 22 inches of rain over a four day period!



This flooding proved to be catastrophic in many areas of the Northwest, but particularly for Mt Rainier National Park, typically a very popular backcountry skiing destination, where the main

access road to Paradise remained closed to the public for six months after the flooding. The flooding was the most extensive in the Park's 108 year history with damages estimated to exceed $36 million! The damage to Highway 123 along the eastern border of Mt Rainer was so extensive that a closure for that highway is expected thru the entire summer of 2007.

Figure 15 Nisqually road and site of the former Sunshine Point campground, MRNP

The flooding in November also cut off access to areas of Mt Hood. This proved especially devastating for Mt Hood Meadows ski area where substantial early season snowfall following the torrential rains lay mostly untracked on the inaccessible mountain while other areas quickly opened amid deep new snow. The rains of November quickly changed to heavy snowfalls that lasted into early January, thus building a substantial early season snow pack with many area snow depths eclipsing 200% of normal by December 1, 2006. This stormy period prompted the NWAC forecasters to begin issuing regular daily avalanche and mountain weather forecasts beginning November 14, 2006.

Figure 16 White River bridge near Mt Hood, OR 11-07-06. Photo courtesy Doug Jones, MHNF.

In the midst of this early season stormy period, the Hanukkah Eve Wind Storm pounded Western Washington. The storm hit on the eve of Hanukkah, December 14th, 2006 and lasted for some 24 hours. One inch of rain was recorded in a one hour period Thursday evening at Sand Point in Seattle where the NWAC is located. The torrential rains were followed by damaging gale-force winds later that night. Wind gusts were clocked at 69 mph at Sea-Tac International Airport setting a new record, while an NWAC weather station on Chinook Pass recorded a 72 mph one hour average wind speed with a gust to 113 mph! This powerful storm caused Governor Christine Gregoire to declare a state of emergency in 17 Western Washington counties. There were 13 storm related fatalities and damage would exceed hundreds of millions of dollars leaving millions of residents without power, many for several days. It would be 11 days before power was restored to all Western Washington customers.

Looking at the trends in snow depths in the Pacific Northwest during previous weak to moderate El Niño episodes (above discussion), a fairly distinct pattern emerged. Generally the seasons began tracking with or nearly so the climate average, until about mid January when a precipitous decline to well below average snow depths occurred that would last through the remainder of the winter. The 2006-07 season began more optimistically than these trends with well above normal averages. However, a strong and well established ridge of high pressure moved over the region from mid January and lasted through mid February. This pattern produced little if any snowfall in the later half of January, lasting into early February and was accompanied by relatively high freezing levels and mild temperatures. This warm period during mid-winter would create a strong melt-freeze crust that would dominate the snow pack throughout the Cascades. The early February crust would also become a bed surface for many future avalanche releases.

A recapitulation of the strong storms early in the season returned for the later half of February, producing another round of heavy snowfalls. For example, Mt Baker received 7 feet of

snowfall in last two weeks of February! It was during this storm cycle that the only avalanche related fatality of the season occurred in the Northwest. On February 24th a skier at Crystal Mountain left the area with his partner and descended into the Mt Rainier National Park that borders the ski area, triggering a three foot slab that carried him some 1500 vertical ft. down the mountain. The NWAC had issued an avalanche watch the previous morning to highlight the expected danger increase, issuing an avalanche warning the morning of the February 24th but apparently neither member of the party was aware of the backcountry conditions.

Figure 17. 3-ft fracture line left side of picture on mid February crust, Park Place avalanche.

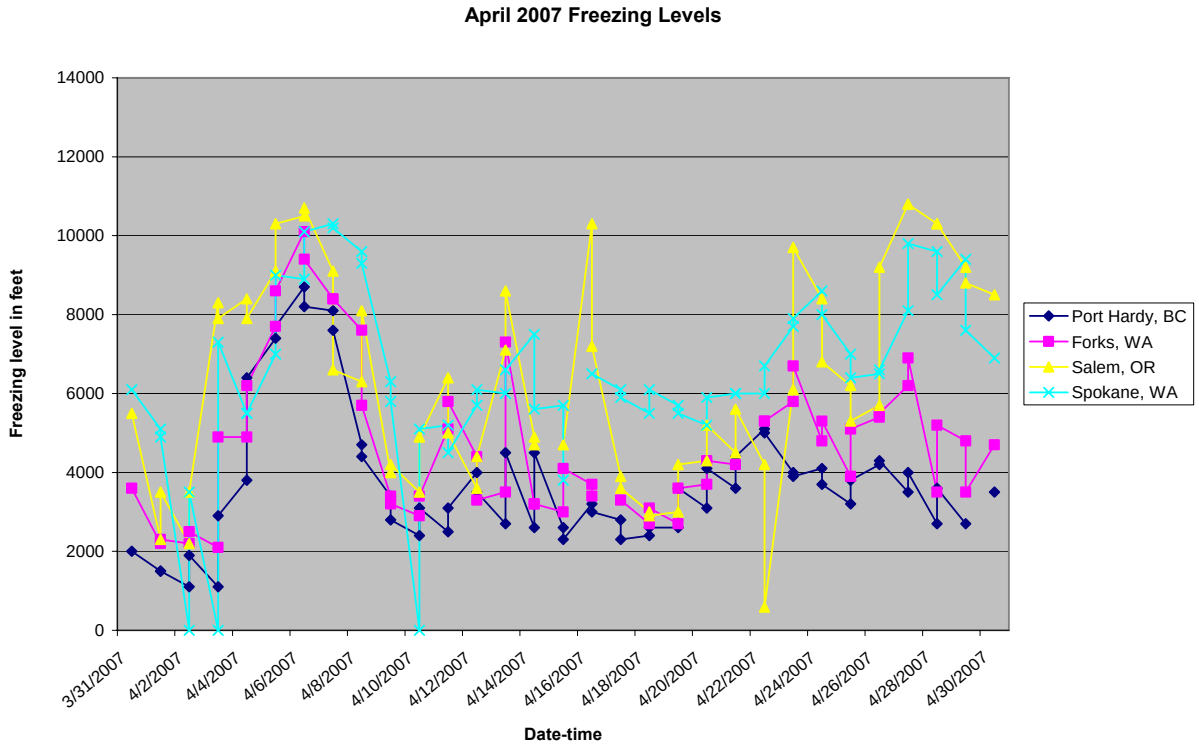
The heavy storms of later February created multiple layers of denser wind slabs of some 1 to 2 feet. This was followed by an additional 1 to 2 feet of lower density snow deposited during a period of generally light winds and very cool temperatures, with the cool temperatures probably also contributing to a weakening bond of the recent snow to a strong crust from early-mid February. Numerous direct action soft slab avalanches were seen during this storm cycle, while the developing snow structure also set the stage for a rather significant avalanche cycle over the first few days of March. An avalanche warning was issued for March 2nd as a result of the expected rising freezing levels along with additional precipitation. In a daily e-mail communication NWAC received from Holden Village near Lake Chelan on March 3rd, it was noted that over 100 avalanches were heard in the valley the previous day! Many other wet snow avalanches were reported along the west slopes of the Cascades during this event as well.

Possibly the most significant avalanche cycle of this mid-late season episode developed over the weekend of March 10th and 11th. With some 2 to 5 feet of snow overlying the strong mid-February crust by this time, it was anticipated that heavy loading could produce slides down to that layer. The weather conditions that developed on March 10 and 11 would cooperate to test this theory. A strong southwesterly jet stream would set up just north of the region with copious

moisture streaming into the Pacific Northwest beginning late Saturday March 10th lasting through Sunday March 11th. Freezing levels with this event rose to about 8,500 feet in the north Cascades and to over 10,000 feet over Mt Hood, with heavy precipitation lasting some 36 hours. During this two day period Mt Baker received 6.7 inches of water, while Paradise on Mt Rainer recorded 4 inches. Stevens and Snoqualmie Passes each had a little over 3 inches. An avalanche watch was issued preceding this warm and wet event with warnings issued during the high avalanche danger on March 10th and 11th. The photo below taken in the North Cascades shows the result of the rain on the recent snow, producing a large slide releasing down to the mid-February crust.

Figure 18. Blue Peak North Cascades rain triggered slide to mid-Feb crust on 3-10 or 3-11, 2007. Photo courtesy Larry Goldie

From mid March through the remainder of the season the snow depth curves began to follow the pattern of previous El Nino winters, eventually dipping below climate averages by late March and early April of 2007. A generally cool and unsettled weather pattern developed from mid spring onwards. The lack of any extended warm periods from mid-March through April allowed the snow pack a relatively slow and peaceful transition toward typical isothermal spring-like conditions and prevented a major wet snow avalanche cycle from developing.



These conditions allowed for the issuance of the spring avalanche statement, with NWAC ending regular daily forecasts on April 15, 2007. Finally sunshine and warm weather arrived from about May 6th with a few days of high freezing levels. A special avalanche statement was issued to cover the expected increase in wet snow avalanche conditions.

The following graph shows how this season's forecasting related to other recent winters in terms of avalanche warnings issued.

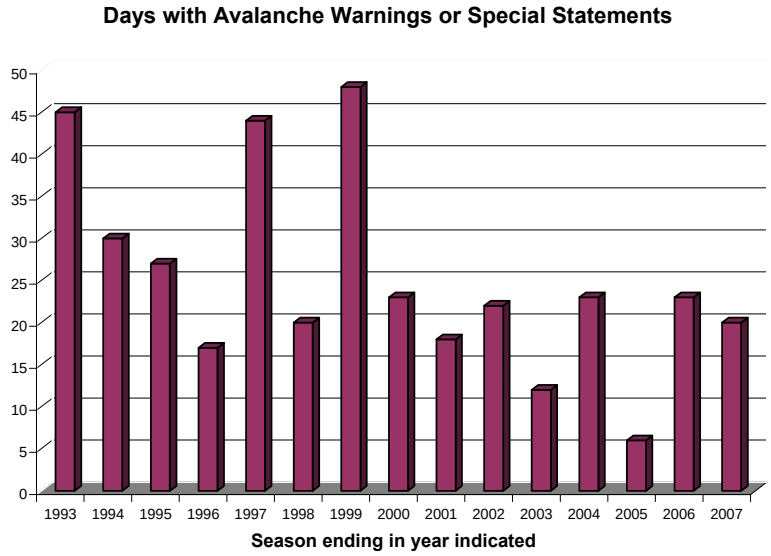


Figure 19. Annual days with Avalanche Warnings or Special Statements, 1993-2007.

2006-2007 SNOWPACK

With the ensuing El Niño many winter enthusiasts were less than optimistic entering the 2006-07 snow season in the Pacific Northwest. However, as the following graphs depict, the snow depths around the region increased rapidly following the early November floods. This ensured above normal depths through the bulk of the winter before eventually falling slightly below normal following a near month long mid-winter dry spell. A renewed storm cycle the last two weeks of February proved to be the final extended snowy period of the winter before a cool but relatively dry spring unfolded.

Figure 20. NWAC total snowdepth chart for 2006/07--north zone.

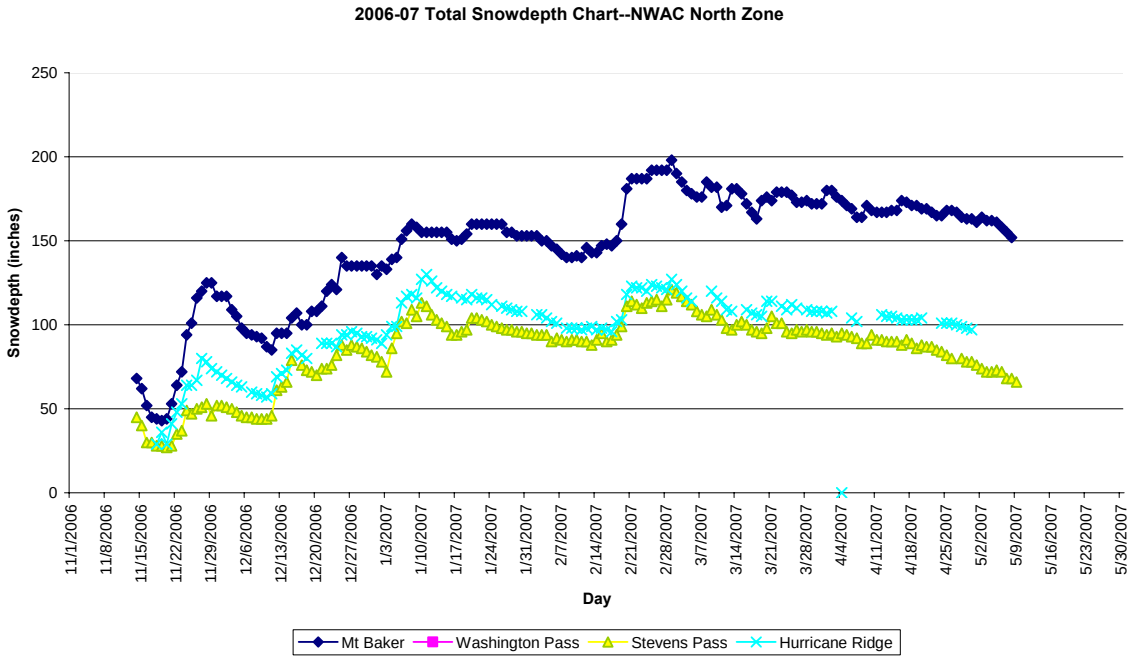


Figure 21. NWAC total snowdepth chart for 2006/07--central zone.

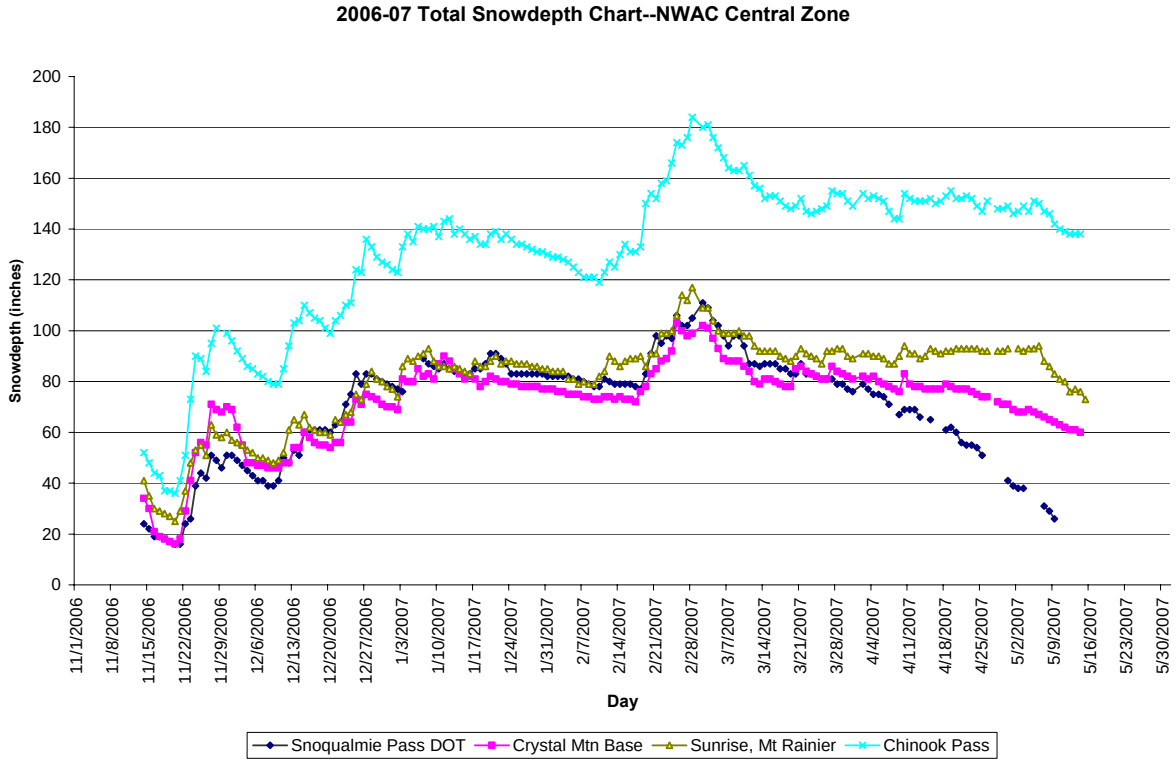


Figure 22. NWAC total snowdepth chart for 2006/07--south zone.

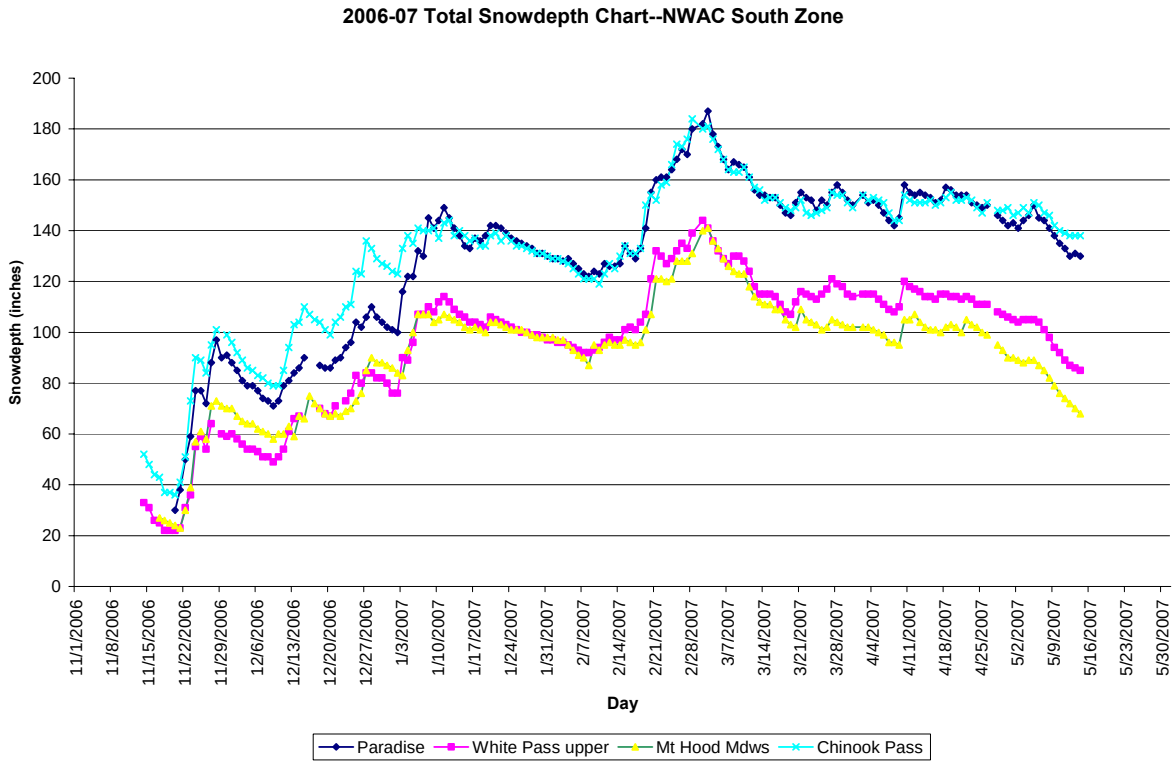
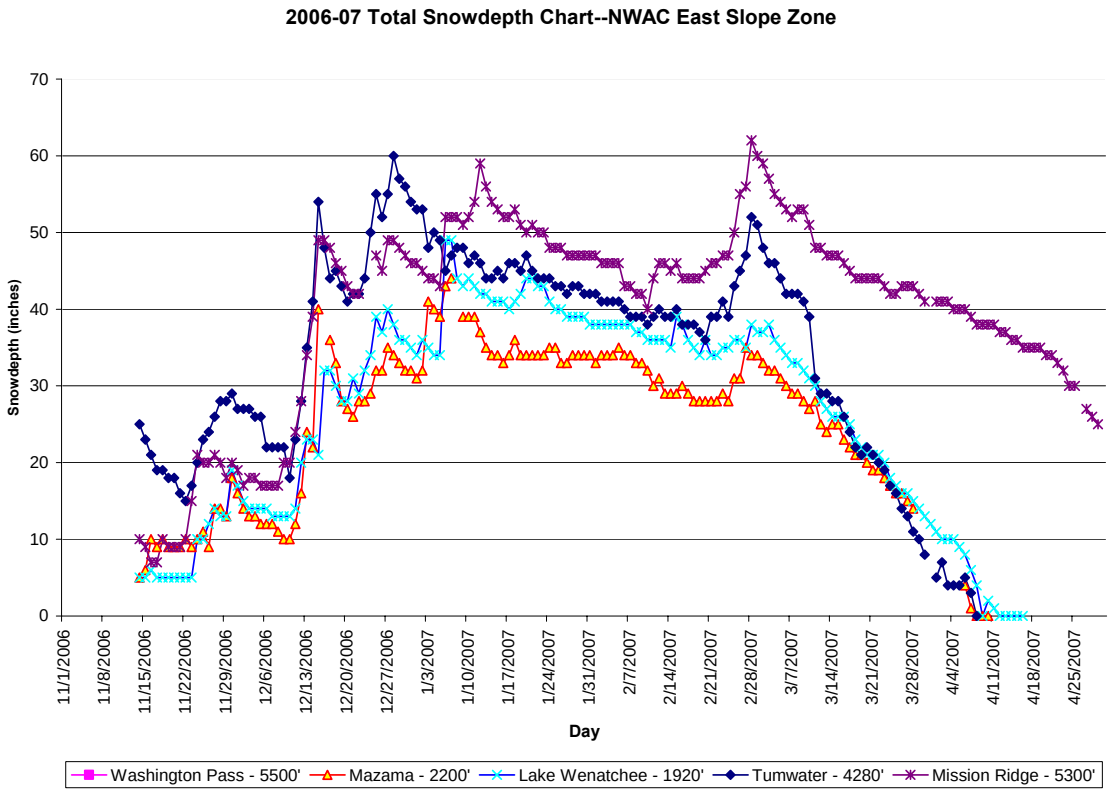


Figure 23. NWAC total snowdepth chart for 2006/07--Cascade east slope zone.



NORTH AMERICAN AVALANCHE ACCIDENT TRENDS

As in many recent winters, the past winter season once again produced too many more avalanche accidents, especially for those who forecast avalanche danger in an attempt to reduce such life changing events. As indicated by the figures below, the long term trend in avalanche related fatalities in the US continues to be maintained at a relatively high level; for the past five years through May 10 of this year, 125 people lost their lives to snow in motion in the United States with over 180 deaths in the US and Canada combined. This is indeed unfortunate, especially since many if not most incidents were probably preventable through either increased awareness, application of knowledge, or being aware of and reducing the human factors that are thought to play an increasingly important role in avalanche accidents. For more statistics on US and North American Avalanche Accidents as well as accident reports, consult the NWAC web site accident page.

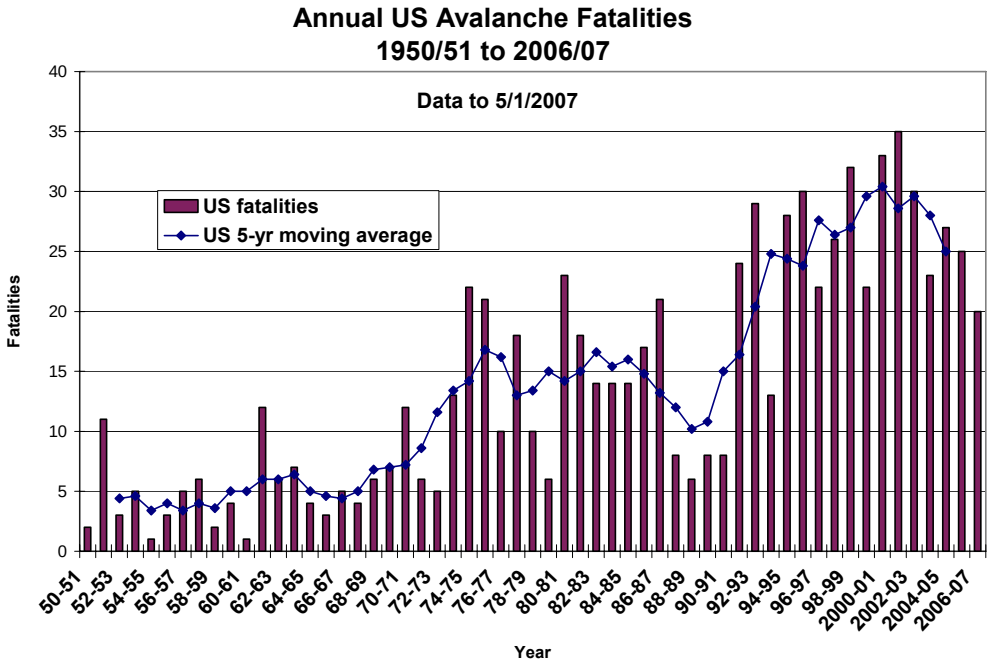


Figure 24. United States Avalanche Fatalities from 1950/51 through 2007: Annual and 5-year moving average valid through May 10, 2007.

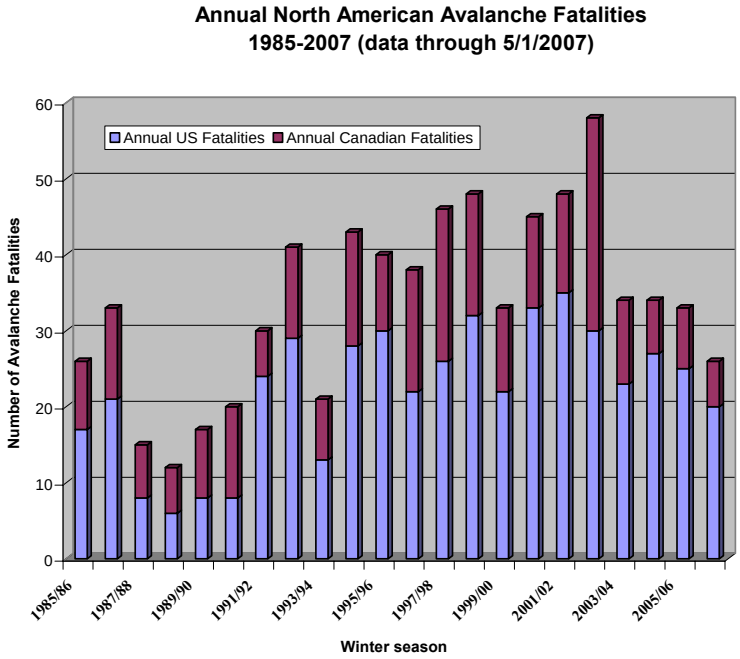


Figure 25. North American (US and Canada) avalanche fatalities by year, 1985/96 to 2006/07. Data valid through 5/10/2007.

As shown by Figures 17 and 18, a relatively large majority of avalanche victims continue to be snowmobilers, both for this past season and for a large majority of the past 10+ seasons. This is due to a variety of factors which include the huge amount of increasingly steep terrain that

newer machines can cover, the added weight of human and machine that more effectively stress a potentially fragile snowpack, and the increasingly extreme maneuvers that many current riders seek and which may trigger a marginally stable snowpack. Another frequent problem occurs when snowmobilers ride up to help other riders on a potentially unstable slope. This doubles the weight and stress on a potential weak layer. If riders would let their friends extricate themselves, it is estimated by some professionals that snowmobile related fatalities could plummet by as much as 50%.

However, by the increasing number of requests from the snowmobiler community for educational talks about avalanche awareness, it is hoped that more and more riders are taking the time and effort to learn about avalanches, snowpack and terrain, and are either accepting or becoming more aware of the consequences and risk that typically accompany riding in extreme terrain.

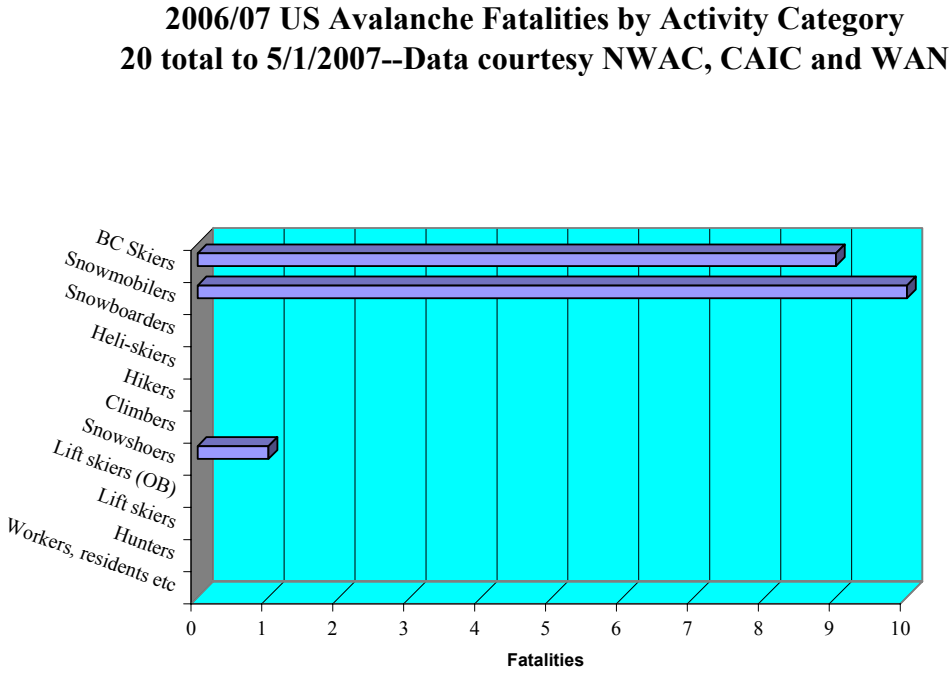


Figure 26. United States avalanche fatalities by category, 2006/07 season. Data valid through 5/1/2007.

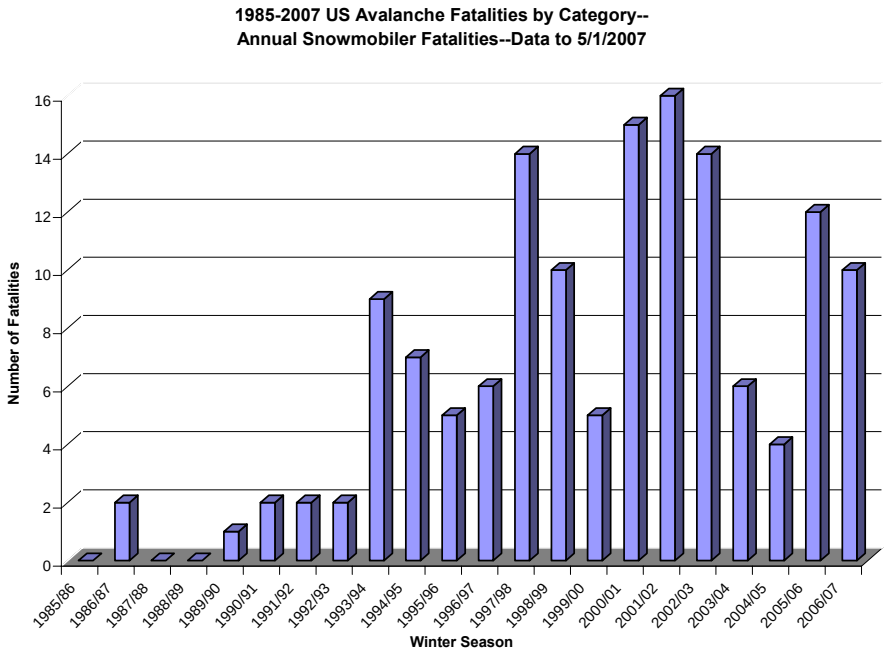


Figure 27. Annual snowmobiler avalanche fatalities in the US, 1985-2006. Data valid through 5/1/2007.

As evidenced by the annual avalanche fatalities by state table below, the distribution of fatalities in the US seems to favor those regions of the country where either weak layers are common and persistent (faceted snow), such as the Rocky Mountain states of Colorado, Wyoming, and Montana, or the intermountain region of Utah where high population areas exist in close proximity to the steep, potentially deep and often unstable snowpacks of the Uinta and Wasatch ranges. However, as indicated by the table Alaskan avalanche accidents are also common. This is due to a combination of factors such as abundantly steep terrain and potential weak layers near a relatively adventurous population in Anchorage and surrounding communities. The relatively high Alaskan accident rate may also be attributed at least in part to the fact that the state has no avalanche centers that prepare and distribute regularly scheduled forecasts of potential avalanche danger. However, this may be changing shortly as the necessary funding to develop and operate such centers is expected to be forthcoming in the next state budget.

Table 2. Annual US Avalanche Fatalities by state, 1985-2007.

UNITED STATES AVALANCHE FATALITIES by STATE 1985/86 to 2006/07 (to May 1, 2007)																								
Winter Season																						22 Years		
State	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	Total	Avg	State
CO	4	11	5	4	4	6	9	12	1	9	7	1	6	6	8	4	6	6	3	5	4	5	126	5.7	CO
AK	0	6	2	0	1	1	2	7	2	6	8	4	3	12	5	4	11	4	3	1	4		86	4.1	AK
UT	5	2	0	0	1	0	5	3	1	5	2	6	2	5	2	6	5	1	4	8	4	4	71	3.2	UT
MT	2	1	0	0	1	0	1	1	6	3	3	1	7	2	2	7	9	4	0	3	4	6	63	2.9	MT
WY	2	0	0	0	0	0	2	1	1	1	3	2	1	2	0	7	2	7	1	0	2	3	37	1.7	WY
WA	2	0	1	0	0	0	2	0	0	1	0	5	2	3	1	3	0	1	7	2	2	1	33	1.5	WA
ID	0	1	0	0	0	0	0	2	0	0	3	3	3	0	2	0	1	3	4	3	4	1	30	1.4	ID
CA	2	0	0	0	1	0	2	1	0	2	0	0	1	1	0	2	1	1	1	3	1		19	0.9	CA
NH	0	0	0	0	0	1	0	0	0	0	3	0	0	0	1	0	0	2	0	0	0		7	0.3	NH
OR	0	0	0	1	0	0	0	1	2	0	0	0	1	1	0	0	0	0	0	0	0		6	0.3	OR
NV	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0		4	0.2	NV
NY	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0		2	0.1	NY
VT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		1	0.0	VT
AZ	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0		1	0.0	AZ
NM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		1	0.0	NM
TOTAL	17	21	8	6	8	8	24	29	13	28	30	22	26	32	22	33	35	30	23	27	25	20	487	22.1	TOTAL

An analysis of the fatal avalanche accidents over the past 10 seasons by NWAC staff shows that a significant number of these incidents occurred in non-winter months and during times when normal daily forecasts were not available. While a relatively high percentage of recent (1996-2007) fatalities have occurred when the forecast danger levels were considerable or high, about 25% have occurred during times of the year when forecasts are typically unavailable.

Figure 28. Northwest fatal avalanche accidents by danger level, 1996-2007.

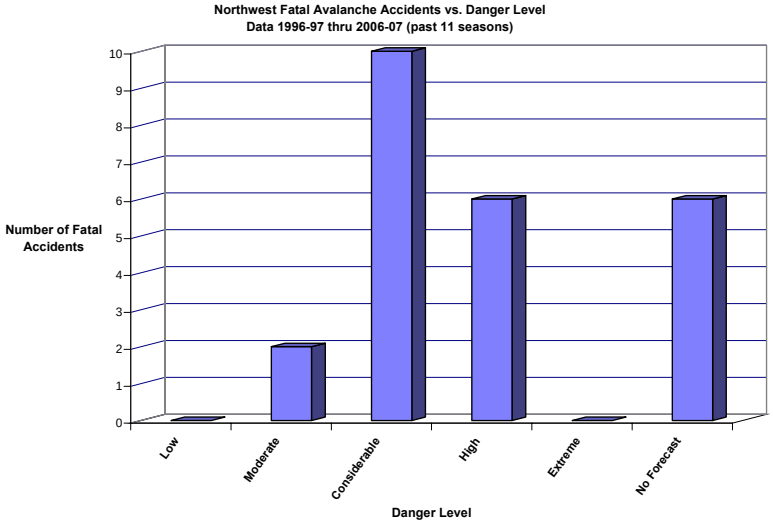
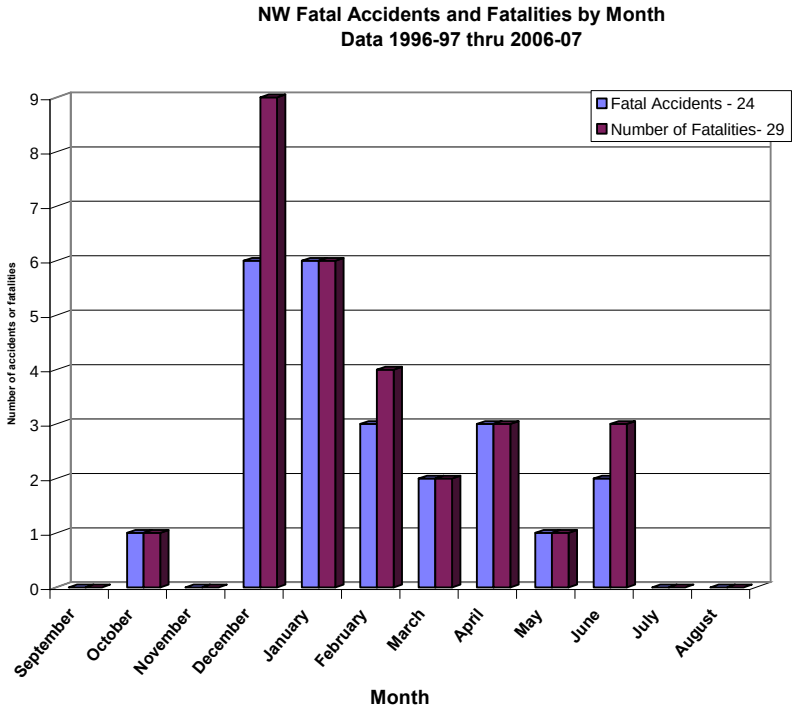


Figure 29. Northwest fatal accidents and fatalities by month, 1996-2007.



Remember that in the mountains, when sufficient snow covers steep terrain, you are at risk from avalanches. So be sure to:

- take some time to learn as much as you can about the threat posed by avalanches,
- be aware of the past, current and future weather trends whenever and wherever you venture into the mountains,
- don't plan for the snowpack structure or stability to meet your expectations,
- always check the snowpack structure no matter what the time of year the calendar indicates,
- plan your routes to minimize your exposure to potential avalanche danger
- check out the NWAC web site for educational topics and links to other snow, weather and avalanche sources,
- review and update your knowledge about avalanche factors,
- read some articles/books on avalanches over the summer,
- plan to attend an advanced or multi-day avalanche awareness training program in the future.

FORECASTING OPERATIONS

Lovely fall weather greeted the forecasters as they returned to prepare for another season of weather and avalanche forecasting duties, education efforts and management of the remote weather station network. The relatively warm and mostly dry conditions allowed for numerous field trips to service and update the extensive mountain weather network that provides the backbone to the operation.

The successful job share during the 2005-06 season between longtime NWAC forecaster Garth Ferber and Knox Williams, former director of the Colorado Avalanche Information Center, came to an end one year ago this spring. Knox and his invaluable contributions to the operation will be missed as he has returned to Colorado to enjoy his retirement and oversee the construction of their new home.

Overall the goals of this job sharing were met, with Knox's contributions to the program an opportunity not to be missed. However, operationally the reduced hours for each member of the shared position were constraining in that it proved difficult to limit hours and still be able to do the work that the position demanded. Also, while the sharing was voluntary, the reduced salary proved to also be very challenging. Garth has returned to his full time position for the winter season of 2006-07. The center is once again headed by Mark Moore with Kenny Kramer and Garth filling out the staff.

The forecasters at the Northwest Weather and Avalanche Center attended the International Snow Science Workshop (ISSW) held in Telluride Colorado in early October. The many stimulating papers and posters presented at the workshop provided a wealth of content as well as many new ideas to consider and share in the coming seasons. One such practical application is a newly developed field test to help determine fracture propagation called the Extended Column Test (ECT). This test is literally an extension of the older and commonly used compression or tap test. Educational video clips on performing and using this test include:.
http://www.avalanche.org/~uac/av-video/ECT/
and
http://www.youtube.com/watch?v=P32eqnrLQ74 .

In addition to presenting a paper on "*Rough Correlations of Common Stability Tests*", Mark also acted as Master of Ceremonies for a most entertaining ISSW banquet. Held every other year at a variety of regional locations throughout the US and Canada, this ISSW was attended by over 800 snow, weather and avalanche scientists and practitioners from over 12 countries, including Switzerland, France, Russia, India and Japan.

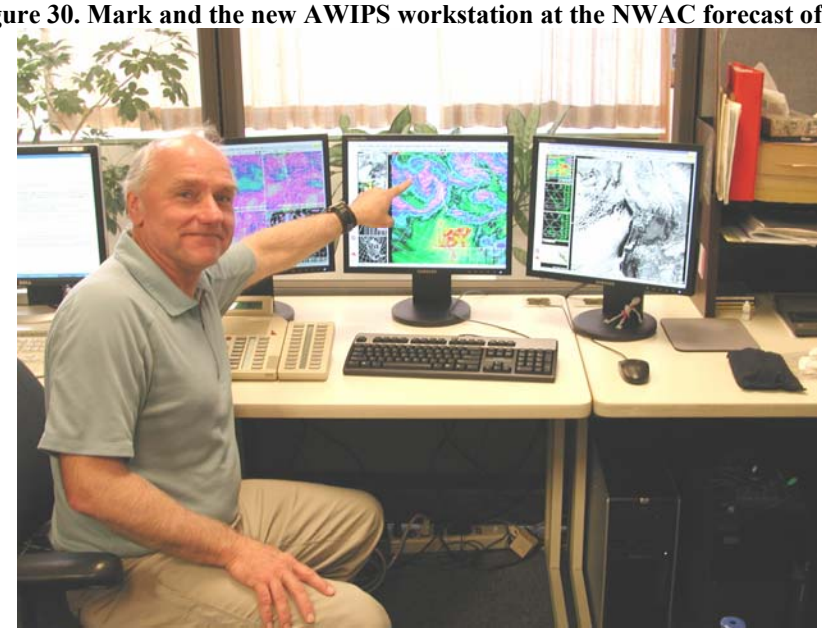
The fall also provided some time to address some needed changes to the NWAC web site. Changes this year included making the forecasts available in html web versions as well as updates to the home page and soon a more consistent web interface via CSS web pages. A local friend/programmer—Tim Kirk—has been responsible for many of the recent updates for the web site. These or future iterations of more graphics oriented templates will eventually allow more dynamic capabilities to be included within the content of the forecasts, including charts, images, video, and graphics. Spring meetings are already planned with several graphics and database volunteers within the FOAC group, with plans to implement some of the recommendations next year.

The trend of increasing requests for NWAC archived weather station data continued this season. Approximately 15 requests for this data were received and answered this season with some large requests. Many of the requests pertained to the record setting rain and wind events in November and December, and the triple fatality climbing accident on Mt Hood in December. Another example of an interesting request was for data from Mt St Helens for 2004 for research into low frequency (infrasonic) generated by recent minor eruptions.

An addition to the FOAC observers program which continues to gain support, the web site now has capabilities to upload snowpit profiles and pertinent avalanche related images. Either click on the above or navigate to the following links—for snowpits:
http://www.nwac.us/snowpits/2006_2007/
and for photos:
http://www.nwac.us/photos/2006_2007/

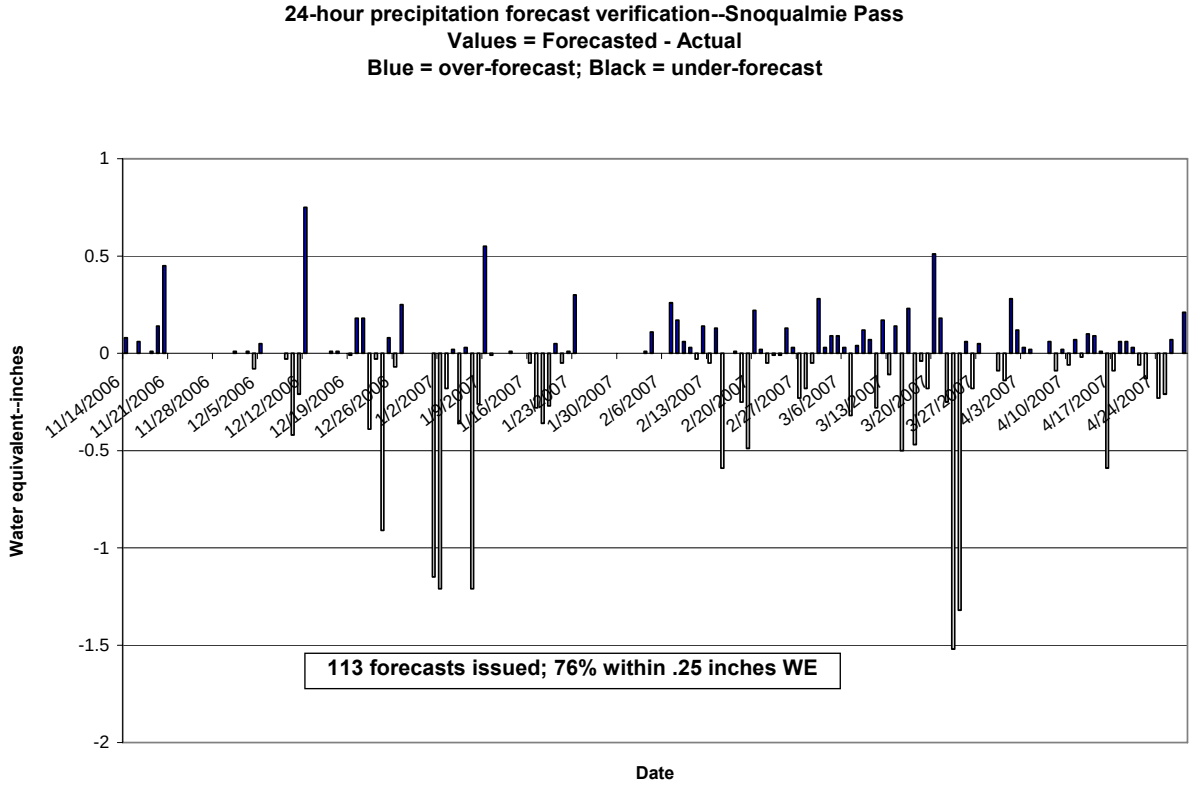
We also received a nice new AWIPS (Advanced Weather Interactive Processing System) workstation this spring. A change was made from an older workstation with 2 screens to a new dual processor station with 3 screens. This will be an aid to managing and analyzing NWS weather data during forecasting shifts.

Figure 30. Mark and the new AWIPS workstation at the NWAC forecast office.



In support of the forecasting needs of the WSDOT at Snoqualmie Pass, the forecasters at the NWAC produced daily 24 hour forecasts of water equivalent at 6 hour intervals. This detailed forecast helped the avalanche crews at Snoqualmie Pass better prepare for and efficiently time avalanche control work on the pass. The graph below shows the accuracy of these forecasts.

Figure 31. 24-hour precipitation forecast verification for Snoqualmie Pass, 2006-07 winter.



EDUCATION

The NWAC provides avalanche awareness talks on request using slides or Power Point presentations. The table below lists the presentations for the 2006-2007 season which reached over 1800 persons.

Table 3. 2006-2007 Avalanche Education efforts by NWAC staff and volunteers.

DATE	GROUP	LOCATION	# ATTENDING	SPEAKER
3 Oct	International Snow Science Workshop	Telluride	800	Moore
21 Oct	Alpine Safety Awareness Program	Bellingham	200	Moore
21 Oct	WA State Snowmobile Show	Puyallup	30	Kramer
22 Oct	WA State Snowmobile Show	Puyallup	30	Ferber
30 Oct	Mountaineers	Bremerton	30	White
22 Nov	WA State Parks Snowmobile Groomers	Cle Elum	40	Kramer
4 Dec	USFS—Okanogan Wenatchee NF	Twisp	18	Ferber, Kramer
5 Dec	Oregon Nordic Club	Portland	20	Emetaz
13 Dec	AMS Puget Sound Chapter	Seattle	35	Moore
14 Dec	Cascadia Wild	Portland	20	Emetaz
16 Dec	Holden Village Staff	Holden Village	40	Emetaz
21 Dec	USFS—Okanogan Wenatchee NF	Cle Elum	40	Moore
4 Jan	WA State DOT	Leavenworth	25	Ferber
8 Jan	The Dalles Snowmobile Club	The Dalles	25	Emetaz
10 Jan	USFS—Okanogan Wenatchee NF	Lake Wenatchee	35	Kramer
10 Jan	Mountaineers	Olympia	40	Emetaz
14 Jan	NAI Level 1	Crystal Mountain	25	Moore
18 Jan	Mountaineers X-C class	Everett	26	White
24 Jan	PLU Geology class	Parkland	24	White
25 Jan	Explorer West Middle School	West Seattle	20	White
25 Jan	Hood River Coffee Shop	Hood River	35	Emetaz
28 Jan	NAI Level 2	Crystal Mountain	25	Moore
3,4 Feb	Portland Mountain Rescue	Government Camp	30	Emetaz
6 Feb	REI	Tualatin	20	Emetaz
7 Feb	REI	Portland	70	Emetaz
20 Feb	REI	Hillsboro	20	Emetaz
14 Mar	Mountaineers	Tacoma	40	Moore, Emetaz
20 Mar	Mountaineers	Tacoma	35	Moore, Emetaz
24 Mar	Mountaineers Scramble class	Everett	40	White
26 Mar	Mountaineers Basic Climbing class	Everett	44	White
3 Apr	UW Graduate Hydrology	Seattle	12	Moore
Total			1868	

During the past 10 years these outreach efforts have reached over 17,000 people.

Table 4. NWAC Avalanche Education Efforts by year, 1997-2006.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Persons	1178	1820	2440	1800	1800	2600	1486	1657	2858	1396	1868
TOTAL	**17,645**										

WEATHER STATION NETWORK

Mt Rainier–Camp Muir – (http://nwac.us/products/OSOMUR)
The NWAC in collaboration with Mount Rainier National Park installed a new weather station in September 2006 at Camp Muir, 10,100 ft. This station (as well as Sunrise earlier) is a result of a national mandate for the NPS to expand its atmospheric monitoring capabilities, both for historical and for climate change purposes. The Muir site is radio linked to a base station at the Paradise Visitor Center 5,400 ft. The station includes the following weather parameters: Temperature, Relative Humidity and unheated Wind Speed and Direction. Although early season flooding at Mt Rainier (mentioned above) took out the power necessary to run the station during late November and early-mid December, once power was restored for the base station the data has been retrieved on a regular hourly basis. To the best of our knowledge this station is now providing the highest elevation publicly available real-time weather data in Washington State.

Figure 32. The new Camp Muir weather station.

Lake Wenatchee – http://nwac.us/products/OSOLAK
http://nwac.us/products/OSODIR
The two new stations near Lake Wenatchee were also installed in September 2006. Funding for these stations stemmed from a BAER (Burned Area Emergency Response) Grant. This grant

was a result of the Dirty Face Fire in the summer of 2005 that destroyed much of the timber in the starting zone of a large avalanche path on the southeast flank of Dirty Face Mountain. The stations were installed to help monitor the snowpack at Lake Wenatchee State Park and winds/temperature at higher elevations near the starting zone. The combination of data obtained from these stations should provide local residents with real time information on the developing avalanche situation on the Dirty Face slide path, and should provide site specific information to aid local forecasting efforts in determining the potential for a large avalanche that could impact recent housing in the lower part of the old historic path. Mark worked closely with several key personnel in the Lake Wenatchee and Leavenworth Ranger District (specifically Cameron Thomas and Matt Karrer) to procure equipment and accomplish the installation. Kudos to all involved for what has become a very reliable site detailing mountain weather conditions near Lake Wenatchee.

Lake Wenatchee State Park Headquarters – The base station is located near the Washington State Park administration headquarters near the northeast corner of Lake Wenatchee at 1,920 ft. elevation. This station includes a full data set including: Air temperature, relative humidity, wind speed and direction, heated precipitation gage, total snowdepth and 24 hour snowdepth measurements.

Dirty Face Mountain—the upper station is located on Dirty Face Ridge nearly 4,000 ft above the northwest end of the lake. This site has excellent wind exposure and measures temperature, relative humidity, wind speed and direction.

Both these sites have been very reliable through the fall and early winter and have provided great information for the forecasters and cooperating agencies as well as the public. The data has helped the forecasters tremendously, especially providing new snow amounts along the east slopes of the Cascades, and helping with verifying atmospheric inversion depths.

Figure 33. Kenny on the completed Dirty Face tower above Lake Wenatchee, WA (old guyed USFS radio tower in foreground)

Washington Pass – A new radio repeater was installed in the late fall on Delancy Ridge between Washington Pass and Mazama by the DOT. This was in hopes to improving the radio connection to the remote weather stations on Washington Pass. Unfortunately this did not solve the problem. New plans are to work with the DOT from the spring to the fall of 2007 in order to find another solution to this problem.

Routine Weather Station Maintenance:

General maintenance and repairs were made at most other stations during between the fall of 2006 and spring of 2007 to help keep the weather station network operational for all.

Alpental – a new datalogger and 12 V battery at the midway station and refurbished radios and different wind sensor lines at the summit.

Government Camp – a new precipitation gage at the base and a new 12 V battery at the summit.

Hurricane Ridge - routine check and initial discussion regarding moving the precipitation and snowdepth instruments to a more suitable location.

Mission Ridge – this system was changed to so that each datalogger is individually contacted, similar to our other stations, from the previous system of only contacting the base station.

Mt St Helens - the old 8" precipitation gage was replaced with a 12" gage in hopes of better precipitation measurements.

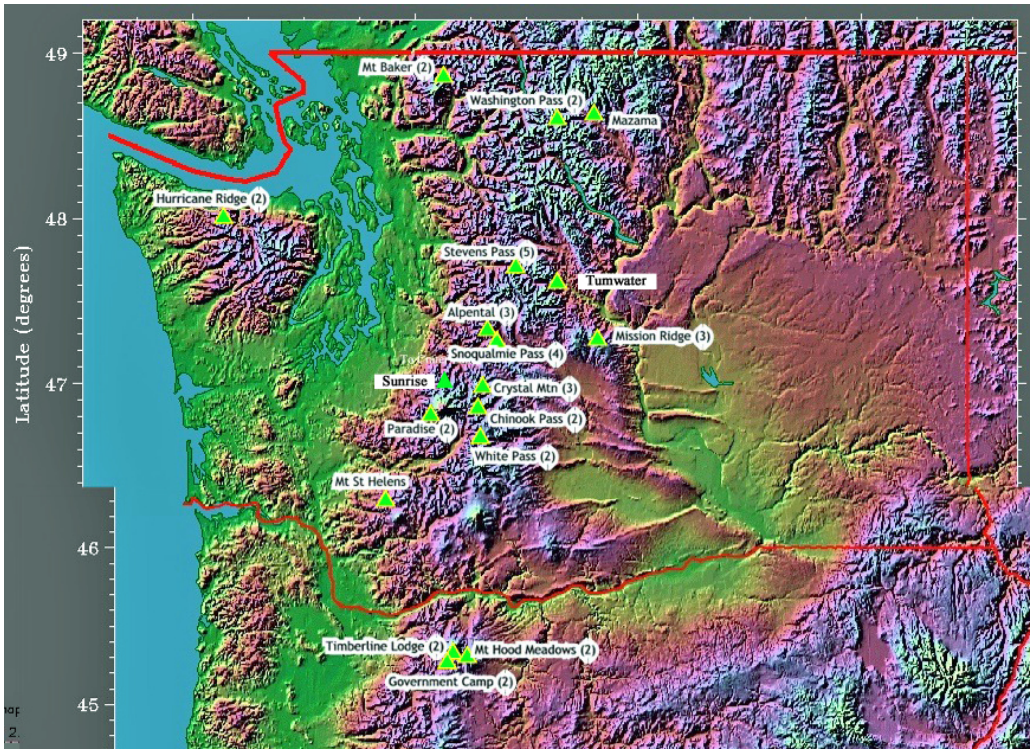
Mt Hood Meadows – new fuses at the wind site.

Stevens Pass – a new precipitation gage for Skyline and a new modem for Brooks.

Sunrise – 2 additional new 12 V batteries and an additional 55 gallon drum for precipitation gage discharge at the base site.

Washington Pass – new precipitation sensor lines and new 12 V batteries at the base site and a new antenna at the wind site.

Figure 34. Map of the mountain weather stations managed and maintained or partly maintained by NWAC staff.



FUTURE WEATHER STATION PLANS

Mt Baker Ski Area – Planned new installation of a much needed upper mountain station to include, ridge-top wind speed and direction as well as temperature and relative humidity sensors. Two way communications to station via either phone line or RF link to base station (planned fall 2006).

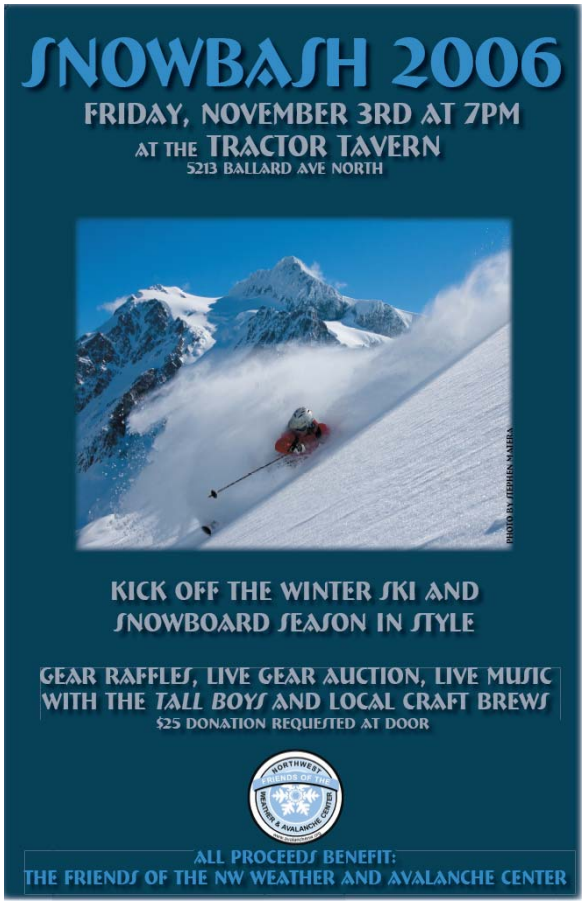
Precipitation Gage Development – Collaborate with Phil Taylor of Taylor Scientific on developing a new all season precipitation gage with versions for either electric or propane heat. Presently there are no commercially available propane heated precipitation gages, while the

electrically heated gages currently used have become increasingly expensive to both purchase and maintain. They have also been very susceptible to the at times intermittent power surges common at remote sites adjacent to ski areas.

FUTURE POSSIBLE ADMINISTRATIVE CHANGE

A bill initially sponsored by Washington State Senator Ken Jacobson, Substitute Senate Bill 5219, was passed unanimously by both houses of the legislature and signed into law by Governor Christine Gregoire on April 20, 2007. As evident from the wording of the bill, the measure itself will not solve the perennial funding dilemmas that the Avalanche Center faces on an annual basis. However, it does stress the importance of the Avalanche Center to Washington State, its economy and the safety of its residents and visitors, and it provides the mechanism and funding for serious dialogue amongst all of its cooperators—federal, state, county, and private—dialogue that is intended to ensure stable long term operation and funding. While it is unclear whether or not this will result in a change of program administration from the federal to the state level, what is clear is strong state support of the Center's existence, both now and well into the future. A series of meetings planned for the next 6-18 months should provide the necessary direction and framework for any future changes in administration, operations or funding that will maintain a secure and effective program.

FRIENDS OF THE AVALANCHE CENTER



The Friends of the Northwest Weather and Avalanche Center (FOAC), an increasingly effective and important NWAC cooperator, promoted the popular SNOWBASH function and fundraiser to kick off the snow season. The 2006 edition proved to be the biggest and grandest thus far, helping to raise funds and awareness for the NWAC. SNOWBASH 2006 was held November 3rd at the Tractor Tavern in the heart of Ballard and included a professionally called live auction, silent auction, gear raffles, great music, comraderie and much more. It was a smashing success! Kudos to FOAC!

The Feathered Friends, an outdoor climbing and backcountry oriented retailer in Seattle, also sponsored a fund raiser for the NWAC on November 8th. A slide show was the highlight of the evening with many equipment manufacturer representatives on hand to provide first hand information about their products. Benj Wadsworth, President of the FOAC, was on hand as well as both Kenny and Garth from the NWAC

to meet and greet the backcountry enthusiasts attending.

NWAC BUDGET AND FUNDING

As has become a common annual theme for the Avalanche Center, increasing funding challenges continue to cloud the future of the NWAC program and associated forecast and data service responsibilities. Despite widespread public support for the program, an uncertain or declining budget within NWAC's long time administering agency—the USDA-Forest Service—has combined with slowly rising personnel expenses and flat or declining contributions from most program cooperators to produce a grim economic situation for the Center. Although the Forest Service recognizes and highly values the continuing contributions and commitment of all cooperators who support Avalanche Center operations, anticipated shortages in future funding levels from a variety of sources have dictated that the Forest Service develop contingency plans for eventual closure of the Center. With a budget shortfall in excess of $50,000 projected for the next fiscal year (FY 2008), it is unrealistic to expect increasing shortages to be filled by either the private sector or donations. This rather grim economic situation resulted in a difficult budget / management decision within the USDA-Forest Service last year regarding the future of the Avalanche Center. At that time, the Frontline Management Team (FMT) within the Mt Baker Snoqualmie National Forest decided that if expected monetary shortages for NWAC operations were not resolved soon with a stable longer term funding solution, the reorganization plan called for a decrease in program services in FY08 (next winter) and subsequent closure of all Avalanche Center Operations in the fall/winter of 2008/09 (FY09).

However, with the recent passage of the "Avalanche Bill" (SSB5219) through the Washington State Legislature and its subsequent signing by Governor Christine Gregoire on April 20, 2007, the Forest Service has extended the reorganization deadline and potential closure of the Center until the results of the meetings and recommendations provided by SSB5219 are known—which is expected in December 2008. As indicated by Sec. 2(4) of the bill document below (and in the link above), status reports and recommendations on the evolving plan "*to ensure that the Northwest Weather and Avalanche Center program has the resources to continue operating at its current level of service into the future*" are due by December 1, 2007, with a final plan and recommendations for the long term viability of the NWAC due by December 1, 2008. It is fervently hoped that the dialogue, recommendations and plan resulting from the bill will establish a long and mutually beneficial relationship with a variety of strong cooperators, and that this new relationship will allow the Center and its services to promote safety of Northwest citizens and visitors well into the future.

CERTIFICATION OF ENROLLMENT

SUBSTITUTE SENATE BILL 5219

Chapter 141, Laws of 2007

60th Legislature
2007 Regular Session

NORTHWEST WEATHER AND AVALANCHE CENTER

EFFECTIVE DATE: 07/22/07

Passed by the Senate March 13, 2007
YEAS 46 NAYS 0

BRAD OWEN

President of the Senate

Passed by the House April 9, 2007
YEAS 98 NAYS 0

FRANK CHOPP

Speaker of the House of Representatives

Approved April 20, 2007, 2:25 p.m.

CHRISTINE GREGOIRE

Governor of the State of Washington

CERTIFICATE

I, Thomas Hoemann, Secretary of the Senate of the State of Washington, do hereby certify that the attached is **SUBSTITUTE SENATE BILL 5219** as passed by the Senate and the House of Representatives on the dates hereon set forth.

THOMAS HOEMANN

Secretary

FILED

April 20, 2007

Secretary of State
State of Washington

SUBSTITUTE SENATE BILL 5219

Passed Legislature - 2007 Regular Session

State of Washington 60th Legislature 2007 Regular Session

By Senate Committee on Natural Resources, Ocean & Recreation (originally sponsored by Senator Jacobsen)

READ FIRST TIME 02/14/07.

AN ACT Relating to the Northwest weather and avalanche center; creating new sections; and providing an expiration date.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF WASHINGTON:

NEW SECTION. **Sec. 1.** The legislature finds that the Northwest weather and avalanche center (NWAC) provides valuable forecasting and education services, provides valuable information to the public, and reduces the impacts of adverse mountain weather and avalanches on recreation, industry, and transportation in Washington state. To conduct its forecasts, the NWAC receives information from the forty-two weather stations it maintains or helps to maintain, consults sources of on-the-ground weather observations, and utilizes information from the national weather service. The NWAC provides mountain weather and avalanche information through a public hotline recording and over the internet.

The NWAC program, which was initiated in 1975, has been administered by the United States forest service since 1976. Throughout its history, the NWAC has been an interagency funded program, receiving significant funds from state, federal, and private sources. However, the NWAC faces funding shortfalls beginning in 2007

and for the foreseeable future, creating the possibility that the NWAC will have to reduce its services or close. It is the intent of the legislature to ensure, in continued cooperation with federal and private sources, that the NWAC receives the resources necessary to continue providing weather and avalanche forecasts for the benefit of Washington state.

NEW SECTION. **Sec. 2.** (1) The state parks and recreation commission shall invite the United States forest service, the national weather service, and the national park service to cooperatively develop an intergovernmental plan and recommendations that seek to ensure that the Northwest weather and avalanche center program has the resources to continue operating at its current level of service into the future.

(2) In developing the plan and recommendations, the state parks and recreation commission shall seek to address issues to include: Administrative control over the Northwest weather and avalanche center program; the physical location of the Northwest weather and avalanche center program; administrative control over the employees, equipment, and facilities of the Northwest weather and avalanche center; and ensuring continued cooperative funding, with equitable contributions from federal, state, local, and private sources, to meet the long-term needs of the Northwest weather and avalanche center.

(3) In addition to the government agencies listed in subsection (1) of this section, the state parks and recreation commission and participating agencies may invite the department of transportation, the interagency committee for outdoor recreation, the United States department of transportation, other relevant state and federal entities, and relevant local governments, including counties along the Cascade mountain range, and private organizations to participate in the development of the plan and recommendations.

(4) The state parks and recreation commission shall, by December 1, 2007, provide an update on the development of the plan and recommendations to the appropriate policy and fiscal committees of the senate and house of representatives. The state parks and recreation commission shall, by December 1, 2008, provide the final plan and recommendations to the appropriate policy and fiscal committees of the senate and house of representatives. The state parks and recreation

commission shall also provide a copy of the final plan and recommendations to participating public and private entities.

(5) The state parks and recreation commission, or any other state agency, may not assume administrative control over the Northwest weather and avalanche center program, its employees, its equipment, or its facilities without specific legislative authorization.

(6) This section expires June 30, 2009.

Passed by the Senate March 13, 2007.
Passed by the House April 9, 2007.
Approved by the Governor April 20, 2007.
Filed in Office of Secretary of State April 20, 2007.

But let us return to the present and the anticipated budgets for both this and next fiscal year. [Federal fiscal years include October-December of the previous year and January-September of the indicated year—e.g., FY 07 runs from October of 2006 through September of 2007). Please note when viewing the budget analyses for FY07 and FY08 shown below that these projections were developed with the additional following assumptions:

- No carryover funds are anticipated from FY07 to FY08
- Flat support levels are expected to continue from most cooperators, including the Forest Service and the National Park Service for the foreseeable future.
- In FY07, NWAC received $31,562 from Title II/RAC programs (North MBS, South MBS and Kittitas). This was approximately $11,500 over the previously projected amount at the cooperator meeting in June of 2006, and helped prevent large shortfalls in FY 07.
- Unfortunately, RAC/Title II monies have not been funded by Congress by the date of this report, and as a result no RAC/Title II funding support is expected for FY08. This lack of monies contributes significantly to the projected deficit of ~$58,000 for FY08.
- Unemployment and Medical expenses of approximately $14,000 are anticipated for forecast staff for the summer of 2007.
- Salaries are projected to increase at approximately +3%/year.
- FOAC has already contributed $5,000 for the current fiscal year and are committed to covering any anticipated shortfall for FY07. With current projections, this overall contribution for FY07 is expected to be approximately $19,000. However, the projection for their contribution in FY08 remains flat at $5,000/year.
- No matter what the final level of program funding turns out to be, all normal forecast and data services will be provided for as long as funding allows (this "all or nothing" program operation has been previously agreed upon with cooperators as the best way to meet future monetary shortages)
- Capital equipment expenditures of $20,000 remain well below fully funded program levels of approximately $30-40,000/year.

Furthermore, in order to achieve continued operation of the Center in FY08 with no additional sources of revenue (other than those previously indicated):

- Capital equipment expenditures will remain well below fully funded program levels of approximately $30-40,000/year.
- Travel and communication costs will remain flat or decrease.
- Unless shortfall is recovered, overall program operation will be reduced by the amount of anticipated shortfall.
- Any shortfalls will result in truncated forecast seasons, with mid-late season forecast operation curtailed by approximately 1 month for each $25,000 of shortfall (or two weeks for each $12,500 of shortfall).
- These ramifications will be discussed at the annual cooperator meeting.

Table 5. Sources of Funding for FY07 and FY08; Total direct and indirect NWAC funding.

NWAC Budget—Sources of Funding

Funding Source	[Direct Support]	FY07 [projected]	FY08 [projected]
Federal		**$111,022**	**$107,000**
	USDA-Forest Service	$75,000	$75,000
	National Park Service	$17,000	$17,000
	USDA-FS Fee Demo	$15,000	$15,000
	USDA-FS Carryover	$4,022	$0
Washington State		**$134,000**	**$134,000**
	Parks and Recreation Commission (includes State General Fund $)	$79,000	$79,000
	Department of Transportation	$45,000	$45,000
	DOT spring forecasting	$0	$0
	Snowpark Program	$4,000	$4,000
	Snowmobile Program	$6,000	$6,000
County		**$31,562**	**$0**
	*Title II/Resource Advisory Comm.	$31,562	$0
Private		**$33,960**	**$20,000**
	PNSAA	$15,000	$15,000
	FOAC	$18,960	$5,000
	Other private	$0???	$0???
TOTAL	**[*Direct Support]**	**$310,544**	**$261,000**
Estimated In-Kind Support (+3% in FY08)		**$179,986**	**$184,711**
[Indirect support]	USDA-FS (~30& of direct cont)	$22,500	$22,500
	WSDOT (obs + equip support)	$22,073	$22,735
	NPS (obs + equip support)	$5,299	$5,458
	NWS (office costs + product access etc)	$64,195	$66,121
	PNSAA (obs, power, phone etc)	$7,325	$7,545
	All (one time cost for data support)	$58,594	$60,352
GRAND TOTAL [DIRECT + INDIRECT]		**$490,530**	**$445,711**

*** Additional funds will be needed in FY08 to allow for full operation**

Figure 35. NWAC—Projected FY07 Expenses

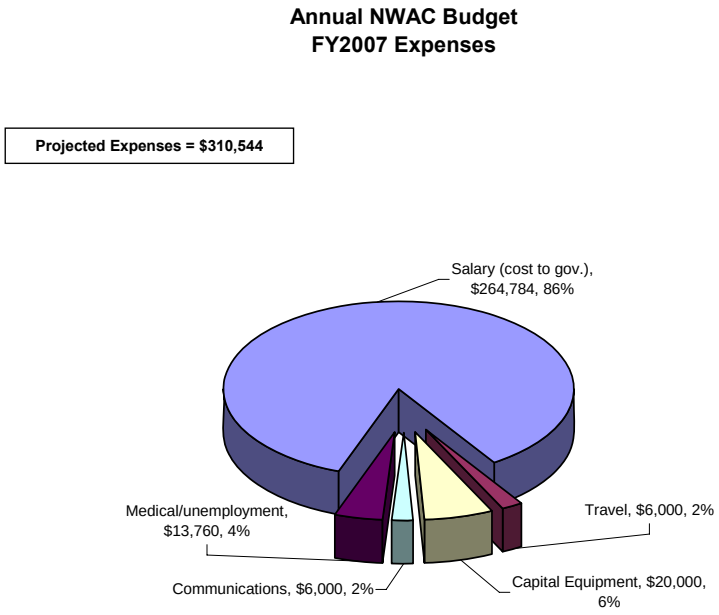
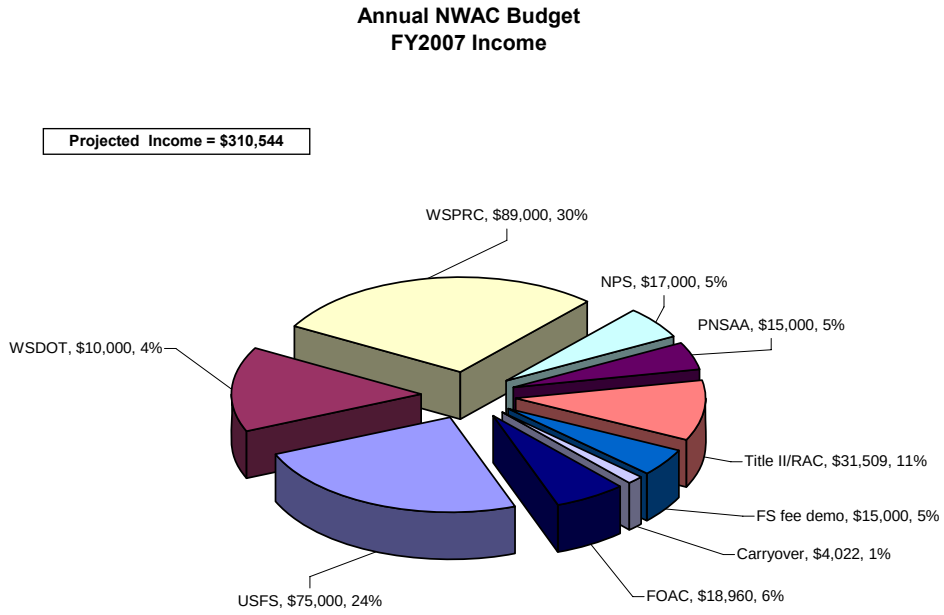


Figure 36. NWAC—Projected FY07 Income



Looking ahead into FY 2008 (winter of 2007/08), the following current NWAC budget projection is indicated:

Table 6. Projected NWAC Budget for FY2008

FY2008--Projected (+3% salary increase PP1)					
Cooperator	**FY2008 Income**	% budget	**FY2008**	**Expenses**	% budget
USFS	$75,000	28.74%	$272,728	**Salary (cost to gov.)**	85.52%
WSDOT	$45,000	17.24%	$6,000	**Travel**	1.88%
WSPRC	$89,000	34.10%	$20,000	**Capital Equipment**	6.27%
NPS	$17,000	6.51%	$6,000	**Communications**	1.88%
PNSAA	$15,000	5.75%	$14,173	**Medical/unemployment**	4.44%
Title II/RAC	$0	0.00%			
FS Fee Demo	$15,000	5.75%			
Carryover	$0	0.00%			
FOAC	$5,000	1.92%			
Donated	[???]				
Shortfall	**-$57,900**				
Total	**$261,000**		**$318,900**		

Naturally NWAC staff and Forest Service administrators will do everything possible to prevent such a significant projected shortfall coming to pass. However, a shortened forecast season in the spring of 2008 is one possible outcome to such a budget, with no or very limited spring forecasting as a result, along with possible adverse personnel action (reducing staff time in pay status).

NWAC STAFF

Biographies and photos of both current and past forecasters at the NWAC are now available on the staff page of the NWAC web site. However, short summaries of current forecast staff (three full time avalanche-meteorologists) during the past winter are also given below.

- **Mark Moore** – Director and forecaster at the NWAC since its inception in 1976. Focal point for budgeting, avalanche accident information, web site management and development, computer and weather station management. Experienced weather station guru.

- **Kenny Kramer** – Forecaster at the NWAC since 1990. Focal point for AWIPS (Automatic Weather Information Processing system) maps and macros, Resource Advisory Committee (RAC/Title II) proposals.

- **Garth Ferber** – Forecaster at the NWAC since 1993. Focal point for weather station programs and data, forecast products, FOAC Snow Pack Information Exchange.

THE LAST WORD

Since you're reading this now you've made it through winter—
To a time of settlement as grains melt and sinter.
But all is not stable in our Northwest snowpack—
Solar demons are lurking and they soon will attack.

While new snow is shallower and the bonding quite good—
When radiation hits, snow weakens as it should.
Stable slopes in the morning are an early delight—
But at the onset of sun may become quite a fright.

Increasing wet slides that result from the sun—
Don't always stay small and are often not fun.
The gooey wet mass that follows terrain—
Is not fun to ride and can bring lots of pain.

While loose at the start larger slabs they can trigger—
And things quickly worsen as you can easily figure.
So while the calendar says spring, snow dangers persist—
Though they probably don't make your top ten list.

So no matter the month, keep track of the snow—
For spring accidents are many as statistics show.
Loss of focus, euphoria, whatever the reason—
Please don't let this be your last spring season

Enjoy and think safe, we'll see you next fall—
Niño or Niña, whatever the call.
Just stay aware through spring into summer—
For avalanche accidents are always a bummer.

- Mark Moore, from the last regularly scheduled forecast for the season on April 15, 2007.

Thanks to Ed

The following remembrance of Ed was published in the *Avalanche Review* shortly after Ed passed away this past year. He was a remarkable man and friend in many ways, and we are all fortunate to have known and shared life with him...

I Remember Ed

by Mark Moore

When I arrived at the University of Washington as a prospective graduate student in Atmospheric Sciences in 1973, I was younger, cocky and frightened all at the same time. I was younger because it was several (?) years ago, cocky because I hadn't started to forecast anything other than food for the next meal, and frightened because Ed was larger than life. His disarming smile and easy manner put the initial fears to rest, at least for awhile. Then on my first wintertime field trip with Ed, I came to the realization that here was someone really thoughtful about life. In early December, back in those years when winter arrived early and stayed late in the Pacific Northwest, my wife and I drove with Ed in his old Ford pickup from Seattle to a snow-cat pickup en-route to Washington Pass. We were heading up to check on one of Ed's research programs that involved avalanche path mapping and path characteristics along the proposed highway corridor for State Route 20 across the North Cascades (stretching from Newhalem to Winthrop). In any case, Ed's pickup was slow and the trip was long—about 3 hours or more of side-by-side camaraderie in the front seat. Trying to engage in conversation and learn from the master, I asked a great many questions. As I recall, to each question Ed replied rather simply, "Yes", or "No", with either little or no elaboration on any point. Quite flustered, I sat there thinking what was wrong, and how could I possibly endure perhaps years of this "failure to communicate". Then it came to me. Ed was waiting for me to ask an "intelligent" question—perhaps something about all of the important observations that I was probably missing as the world flowed by the pickup window.

Anyway, when we arrived at the closed highway gate above Ross Lake, piled out of the pickup, and got our touring gear together to await our snow-cat pickup, I noticed Ed keenly looking around and intensely interested in most everything around him. When I realized that this was the learning process that he hoped I'd pick up on, we immediately got into an engaging and quite interesting conversation about hoar frost (which was everywhere), when and where and how it formed, and how important it was as a weak layer. From then on, if I was observant and thoughtful about the world around me, from variable snow depths to wind effects to changes in terrain, I never seemed to be at a loss while talking with Ed—who was always intimately examining and analyzing everything natural surrounding him. The rest of the trip was mind expanding for me as we ski-jored up behind the Thiokol for some 15 miles from the gate to the Washington Pass summit. There a small portable A-frame lay between the base of rather imposing Liberty Bell Mountain and adjacent Cutthroat Ridge and acted as the winter home for Frank and Donna, the UW/Washington State Department of Transportation avalanche activity observers back in the winter of 1973-74. As we observed and examined the multitude of avalanches that had recently hammered the basin all around us, and Ed's keen eyes sparkled with interest and enthusiasm, I knew that my true education as an avalanche forecaster had begun.

For the next several years as a graduate student, I was fortunate to have Ed as a rather constant source of enlightenment, and an excellent critic of my fledgling thesis abilities. His guidance ensured that I critically evaluate everything that I wrote, and that I stated each point as carefully and completely as possible. Though he attempted, unsuccessfully, to refine and shorten (succinctify?) my somewhat lengthy and verbose writing style, it is to his credit that he

persevered and at least made what I did say have some reasonable content, rather than just a ramble without purpose. Yet Ed was certainly not all grim work, re-writing papers, teaching or research. He enjoyed laughter more than most and when he laughed it was a whole body deal. Ed had a great passion for many things, and shared his passion for snow and weather science through great classes and teaching expeditions. His "Ski the West" college course (a nickname for a more profoundly named research class) at UW was imminently popular, and why not—after several weeks of classroom instruction, Ed loaded his students into a UW van, embarking upon a snow and avalanche survey of many western mountain locations to verify and expand on what they had learned. Of course this involved lots of downhill time at a variety of powdery areas. Though we all garnered lifetime benefits from the course, we also learned that mountain time was fun time with Ed. Rich Marriott, Sue Ferguson, Pam Hayes and Dave McClung all participated in this course which received uniformly high marks for student satisfaction. Ed took every opportunity to be away from the office and out in the field, and I don't remember any of his graduate students having research projects that didn't involve many, many field trips.

Although many of us knew or think we knew Ed well, I believe that there is a part of him that is/was quite unknown. It's the part that was "Obie Juan", the mystical Ed, the snow wizard who's mind was often a step or two ahead of his colleagues. One evening while celebrating the anniversary of the "Avalanche Review" with Sue Ferguson, Rich Marriott and several other graduate students, Ed pranced into a rooftop party-meeting of the UW Atmospheric Sciences Avalanche Group wearing long purple robes, a pointed magician's hat, and bearing a large flask of a potent mix dubbed "Snow Snake Oil". Unfortunately, as the evening evolved, Ed brought the level of levity way up, was way too generous with the SSO concoction, and I was far too eager to sample it. I do believe that he chuckled continuously later that evening as he and Meg drove my semi-comatose body home in the old VW microbus. But what else could you do while watching the hit movie "Avalanche" starring Mia Farrow and Rock Hudson? While my recollection of this stunning box office flop is dim, I do remember that it was not noted for either its acting or special effects. In any case, it was a history of antics such as this interspersed with amazing insights and wisdom about most anything that for me sealed his reputation as a grand snow wizard, a reputation which has been reinforced many times in many ways over the intervening years.

Many of us have special memories about Ed, what he meant to us personally and to the avalanche community as a whole. But the common theme is that we will all miss Ed. Although I presented this at Ed's intro at the ISSW06 banquet, it seemed fitting to include it again here. It sums up my ramblings above, and Ed would have been pleased for such brevity, with content of course...

For Ed

A long time ago in a place far away,
A place that it rains most every day—
A young student came, fresh off the beach,
He came to be molded for his mentor to teach.

He didn't know very much about snow,
What made it stay or what made it go—
He didn't know that it had energy and strength,
Or that it had structure along its whole length.

But the master was patient and chuckled a lot,
And I'm sure to himself he gave it some thought—
What do I have here, that I'm expected to mold?
To teach so that he'll learn and live to grow old.

This youngster must think about weather and terrain,
And how new layers form through snow and from rain.
And he's got to be quick to respond and transform,
Even through stability is often the norm.

Now this scene's been repeated an amazing number of times,
I could fill in lots of your names by just having more rhymes.
You've touched many lives with deep wisdom and thought—
And many of us here say, "Thanks Ed, thanks a lot".

Figure 37. Ed LaChapelle and Meg Hunt outside their McCarthy, AK home, summer 2005