J9.13 THE SIERRA WEATHER & AVALANCHE CENTER

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1. INTRODUCTION

Firnspiegel LLC is an atmospheric and snow research & consulting company based at Lake Tahoe, California, in the Sierra Nevada Mountain Range. During the 2000-2001 winter season Firnspiegel launched the Sierra Weather and Avalanche Center (SWAC). The center disseminates regional Sierra avalanche and weather forecasts on a daily basis via its web site.

The numbers of backcountry users (e.g., skiers, snowboarders, snowmobiles) have increased dramatically over the past ten years. This increased use along with new technologies has spurred the formation of the Sierra Weather and Avalanche Center. SWAC is merging the use of GIS technology with weather and avalanche products to more easily visualize forecast information. The weather and avalanche center is based on the need for avalanche forecasts with increased spatial and temporal resolution.

2. WHY A NEW AVALANCHE CENTER?

Why a new avalanche center? The Sierra Nevada Range encompasses an area of 3,800 square miles and the average annual snowfall varies from 50 to over 500 inches. Figure 1 shows the approximate area of coverage of SWAC. Prior to the establishment of SWAC only one blanket avalanche forecast was provided for the northern Sierra and one for the southern Sierra. More detailed and site-specific forecasts are necessary as there are sharp regional and local-scale gradients in weather and climate behavior. The Sierra are unique in the snowfall they receive, as they are affected by both maritime and continental air masses. As over 80% of Sierra avalanches are weather-related thus bringing together weather forecasting and snow science was a logical and necessary combination.

The Sierra Weather and Avalanche Center disseminates daily weather and avalanche forecasts during the avalanche season. Figure 2 is a forecast that was issued on December 1, 2000, via the SWAC website. In addition to this forecast users are able to point-and-click to obtain 3D avalanche hazard forecasts for the most popular backcountry destinations. As SWAC is entering its second season of operation it is anticipated that as more funding is secured more detailed, site-specific, forecasts will become available. These forecasts are generated by both meteorologists and avalanche scientists working together. Remotely sensed data along with field observations are used to estimate the water content of the snowpack in the different regions of the Sierra. Much of the field work is accomplished using snowcats, snowmobiles, and human-powered (hiking/skiing) access to remote locations.

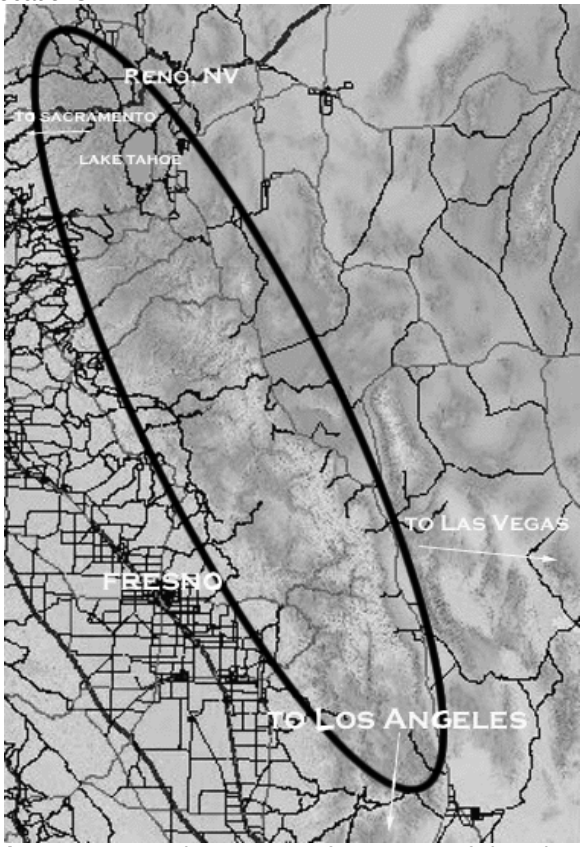

Figure 1. Approximate area of coverage of the Sierra Weather & Avalanche Center forecasts.

The Sierra Nevada mountain range is heavily used due to the large population centers surrounding the range (e.g., San Francisco, Sacramento, Los Angeles, and Reno). The number of backcountry users has increased dramatically over the past ten years. This increase is due to many factors including the following.

- New ski/snowboard technologies allowing people with only moderate skills to enjoy the backcountry.
- Snowmobile technologies have given riders the ability to push further into the backcountry. This technology includes new snowmobiles with “paddles” and increased horsepower.
- Population increases in California and Nevada.

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- More people venturing into the backcountry to escape crowded ski resorts.

CURRENT CONDITIONS

December 1, 2000
Ward Peak, California
ELEVATION: 8,500 feet PITCH: 33 degrees
AIR TEMP: -3°C WIND: SW at 25 mph

Seasons Greetings from Firnspiegel…

The northern Sierra picked up substantial amounts of snow during the past several days. The Sierra Weather & Avalanche Center staff took the opportunity, with the clearing weather, to do a hasty pit analysis of recent accumulations. We surveyed a direct north-facing slope with a 33 degree pitch at an elevation of 8,500 feet. This lee slope experienced substantial wind loading during the three storms beginning on 12/11/00 and ending early on 12/15/00. We found a total pack of 76 inches (193 cm) and storm period accumulations of 42 inches (107 cm). New snow totals for the period of non-wind loaded slopes were somewhat less.

The storm period began with cold stellar snow and densities in the 7% to 9% range. The period ended with warmer weather, southwesterly winds of 50-70mph, and snow densities of 20%-25%. The bond between the high density new snow (40 inches or 102 cm) and the older cold snow was not impressive and failed easily during our probe shear test. This was mitigated somewhat by the cohesiveness of the high density new snow. We observed a compression failure during the stuffblock test from a height of 20 inches (50cm). The failure occurred at 65 inches (165cm) above the ground. The stuffblock results coincide with a "potentially stable" result on the Rutcshblock Scale.

Figure 2. Avalanche forecast for the northern Sierra issued by SWAC on December 1, 2000.

This increased use has lead to an increase in the number of avalanche fatalities in the United States since the 1950's (Figure 3). Of this increase in avalanche fatalities, snowmobilers lead the list with twice the number of fatalities as any other activity (Figure 4).

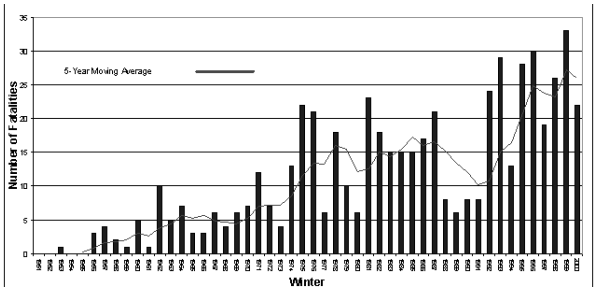

Figure 3. Number of avalanche fatalities in the United States by year from 1950-2000. The five-year moving average is also shown. (Source: American Avalanche Association).

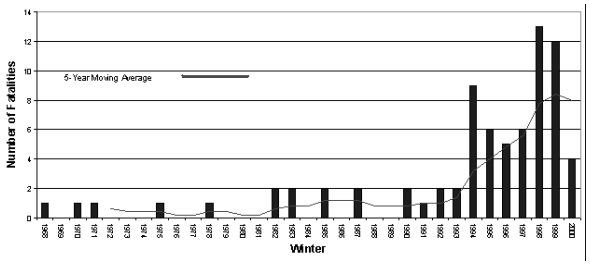

Figure 4. Number of U.S. snowmobile avalanche fatalities by year from 1968-2000. The five-year moving average is also shown. (Source: American Avalanche Association).

2. SPECIALIZED FORECASTS USING GIS

The Sierra Weather and Avalanche Center makes use of Geographic Information Systems (GIS) technology in order to enable users to accurately visualize information about the mountains. GIS creates 'smart maps' that are embedded with information such as aspect, elevation, slope angles, and land-use. These maps can then be queried by the GIS user to display information such as the location of certain avalanche-prone slopes. The maps can then be color coded so that avalanche-prone slopes are represented by a certain color. SWAC uses the United States Avalanche Danger Level colors. Table 1 is the United States Avalanche Danger Scale. The colors represent different levels of hazard such as green for low danger and red for high danger These colors are overlaid on a 3-D terrain map and supplied to the public, creating a powerful and useful visual avalanche forecast. This is a huge change from text-only avalanche forecasts that have been the industry standard.

Figure 5 is a sample (in black & white for this publication) of a 3D avalanche hazard forecast. For a full color image and movie using the U.S. avalanche danger scale please see the Firnspiegel web site linked with this paper on the AMS (American Meteorological Society) web site.

HAZARD LEVEL	PROBABILITY OF AVALANCHES	
	NATURAL	HUMAN-TRIGGERED
LOW (Green)	Very Unlikely	Unlikely
MODERATE (Yellow)	Unlikely	Possible
CONSIDERABLE (Orange)	Possible	Probable
HIGH (Red)	Likely	Likely
EXTREME (Black)	Certain & Widespread	Certain & Widespread

Table 1. U.S. Avalanche Danger Scale (for full danger scale and description please see Firnspiegel web site).

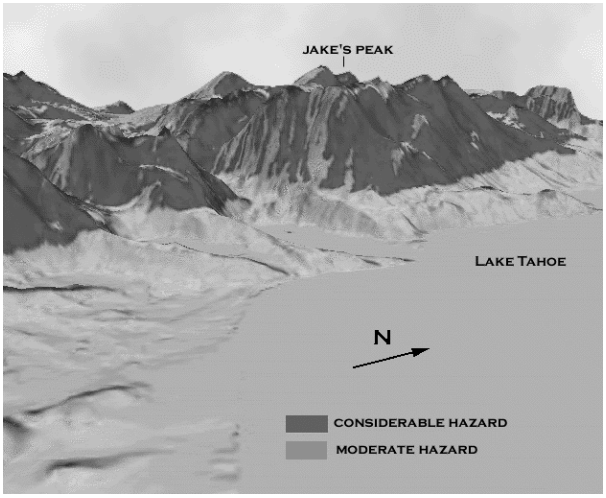

Figure 5. Sample avalanche hazard forecast showing graphically slopes with considerable and those with moderate avalanche hazard around a portion of Lake Tahoe.

Visualization is a powerful tool used towards understanding, allowing the possibility of recognizing a safer route that might not have been considered previously. Potential users of SWAC such as backcountry travelers, will benefit greatly from the use of GIS-driven avalanche forecasts, allowing them to more easily visualize forecast information and avalanche terrain.

3. POTENTIAL USERS OF SWAC

Users of SWAC will be able to pint-and-click on area maps to zoom in on their specific area of interst. There will be an emphasis on snowpack stability analysis in the avalanche forecasts. The possible users of the Sierra Weather & Avalanche center include:

- Backcountry travelers
- Local Safety Services
- Transportation Departments
- General Public
- Mountaineers
- Local Governments
- Ski/Snow Industry

Due to the wide variety of SWAC users, the forecasts include 3D graphical information, layman's text forecasts, forecasts and stability test information for more skilled snow science users, and snow pit plots for avalanche experts. An example of a snow pit plot from the 2000-2001 winter season posted on the SWAC website is shown in Figure 6.

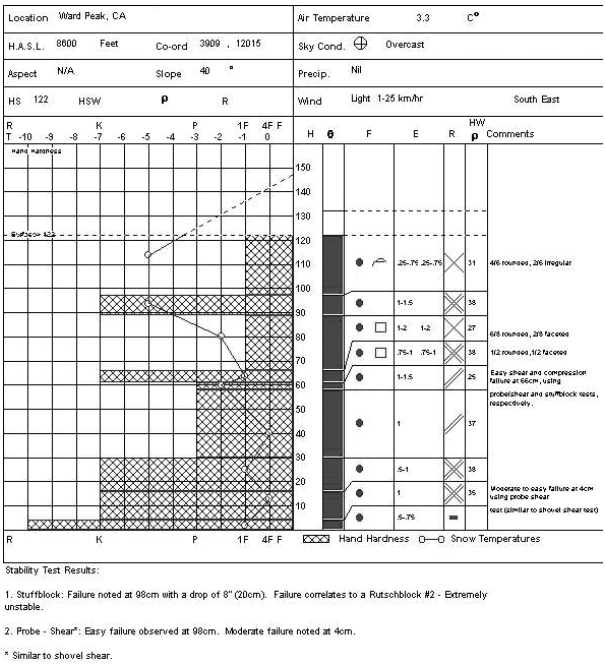

Figure 6. Portion of a snow pit plot from the 2000-2001 winter season posted on SWAC website.

4. AVALANCHE EDUCATION

In 95% of all avalanche incidents the victim or someone in the victims' party triggers the avalanche. The statistics scream out the need for avalanche education. The typical avalanche victim is a white male between the ages of 18 and 35, educated, and whose excellent athletic skills far outweigh their avalanche skills. Figure 7 is a plot of avalanche fatalities in the United States versus activity. Avalanche victims are almost exclusively backcountry recreational users: snowmobilers, climbers, snowboarders, snowshoers, skiers, and hikers. Snowmobilers lead the list with almost twice the number of fatalities than any other activity (Figures 4 and 7).

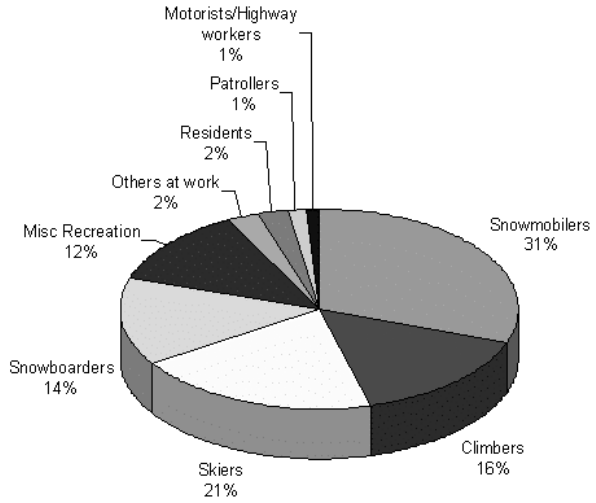

Figure 7. Graph of avalanche fatalities in the U.S. versus activity (from 1995-2000). A total of 161 fatalities were reported in the United States during this period. (Source: American Avalanche Association).

The SWAC education and outreach programs include television appearances, radio addresses, newspaper articles, school visits, and college internships (to-date: University of Nevada at Reno and Sierra Nevada College). SWAC anticipates expanding the educational and public outreach programs during the 2001-2002 avalanche season by establishing additional collaborations and providing additional services such as establishing an avalanche hot-line.

5. CONCLUSIONS

The Sierra Weather & Avalanche Center was launched during the 2000-2001 winter season. As SWAC enters its second avalanche season the forecast center plans to increase and improve users of the Sierra access to (1) current snowfall and snowpack observations, (2) current weather data, and (3) dissemination of avalanche and winter recreation information for a SPECIFIC AREA OF INTEREST. Users are able to point and click on area maps to zero in on their area of interest.

6. REFERENCES

American Avalanche Association: web site location: http://www.avalanche.org/~aaap