# **10.12** Wind-Profiler Derived Snow Level Monitoring: California Highway I-80 Donner Summit

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## 1. INTRODUCTION

Recent advances in wind profiler technology at NOAA/ETL (Environmental Technology Laboratory) have created the capability to monitor the altitude of the snow level in storms approaching and striking the Sierra Nevada mountains. The goal of this operational project is to improve the accuracy of short-term (0-24 hours) snow level forecasts for winter storms affecting the Sierra Nevada mountains near Donner Summit as well as evaluating the potential use of these data in the decision-making process for highway snow operations.

## 2. SNOW-LEVEL DETECTION

The NOAA environmental Technology Laboratory has developed an objective algorithm to detect the bright-band height from profiles of radar reflectivity and Doppler vertical velocity collected with a commercially available Doppler wind profiling radar. Figure 1 shows statistically good comparisons of bright-band heights with melting levels and temperature lapse rates measured below the melting levels. The snow level algorithm specifics are detailed in White, et al, 2002.

## 3. THE DONNER SUMMIT PROJECT

Interstate 80 is the major highway that traverses through the Sierra Nevada mountains. Donner Summit is the highest point along I-80 in the Sierra. Donner Summit (elevation 7,227 feet) receives an average of 409 inches (1,039 cm) of snowfall a year with the least snowiest year in 1881 receiving only 153 inches (389 cm) and the snowiest year in 1938 receiving 819 inches (2,080 cm). Another impact of snow level on the Sierra is of course accurate forecasts for the traveling public and interstate trucking.

The specific goals of this project are:

- to improve the accuracy of short-term (0-24 hour) snow-level forecasts for winter storms affecting the Sierra Nevada Mountains near Donner Summit, and
- to evaluate the potential use of these data in decision-making for highway snow operations.

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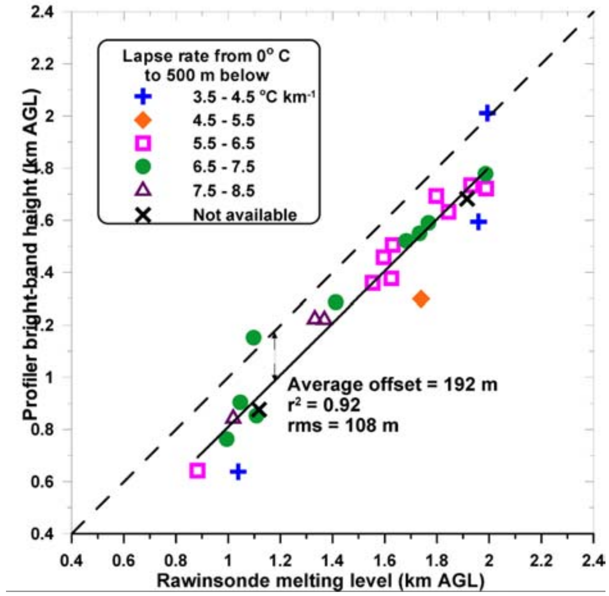


**Figure 1.** PACJET Bodega Bay wind profiler results. Comparison of bright-band heights with melting levels and temperature lapse rates measured below the melting levels.

Profilers deployed along the coast and in the western Sierra foothills as part of the PACJET (Pacific Landfalling Jets Experiment) (Figure 2) have provided data that are being used to tests these concepts (Ralph, 1995; Ralph, et al, 1999; and Koch and Ralph, 2000). Initially, it appears that the coastal wind profilers can provide a 4-12 hour lead-time on snow level information along I-80 in the region of Donner summit.

## 3. CASE STUDY

Case studies have been analyzed that give between 4 and 12 hours of lead-time. The case study being presented here gave four hours of lead-time. On February 19-20, 2001, a storm approached the California coast and struck the Sierra Nevada mountains producing 1 to 2 inches of rain at the coast and 14.7 inches of snow (8.3% water content snow) fell at Donner Summit. The storm was characterized by two primary clouds bands and their associated precipitation. The satellite images in Figure 3 indicate that at approximately 1030 UTC on 19 February 2001 the first significant rain band associated with the leading frontal cloud band reached the California coast near Bodega

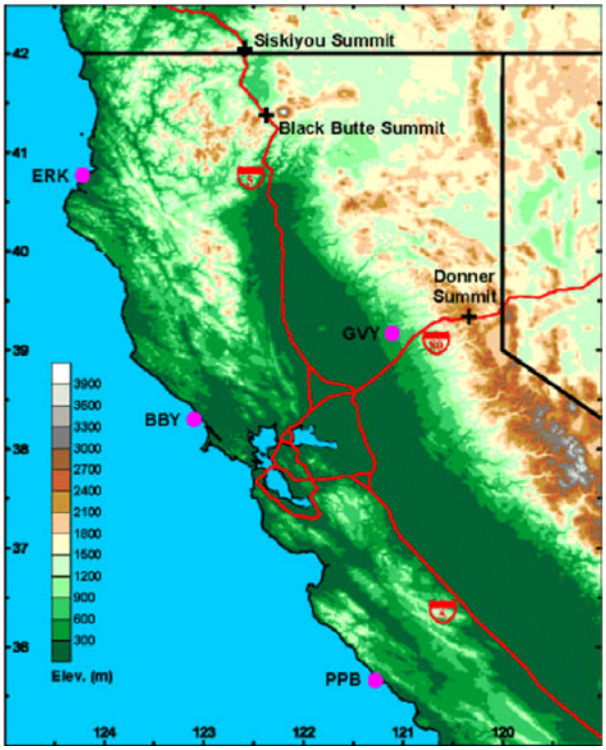


**Figure 2**. California base map identifying three summits crossed by U.S. Interstate Highways (I-5 and I-80) and the locations (north to south) of NOAA/ETL wind profilers used for snow level detection during PACJET (Jan. – Mar. 2001): Eureka (ERK), Grass Valley (GVY), Bodega Bay (BBY), and Point Piedras Blancas (PPB).

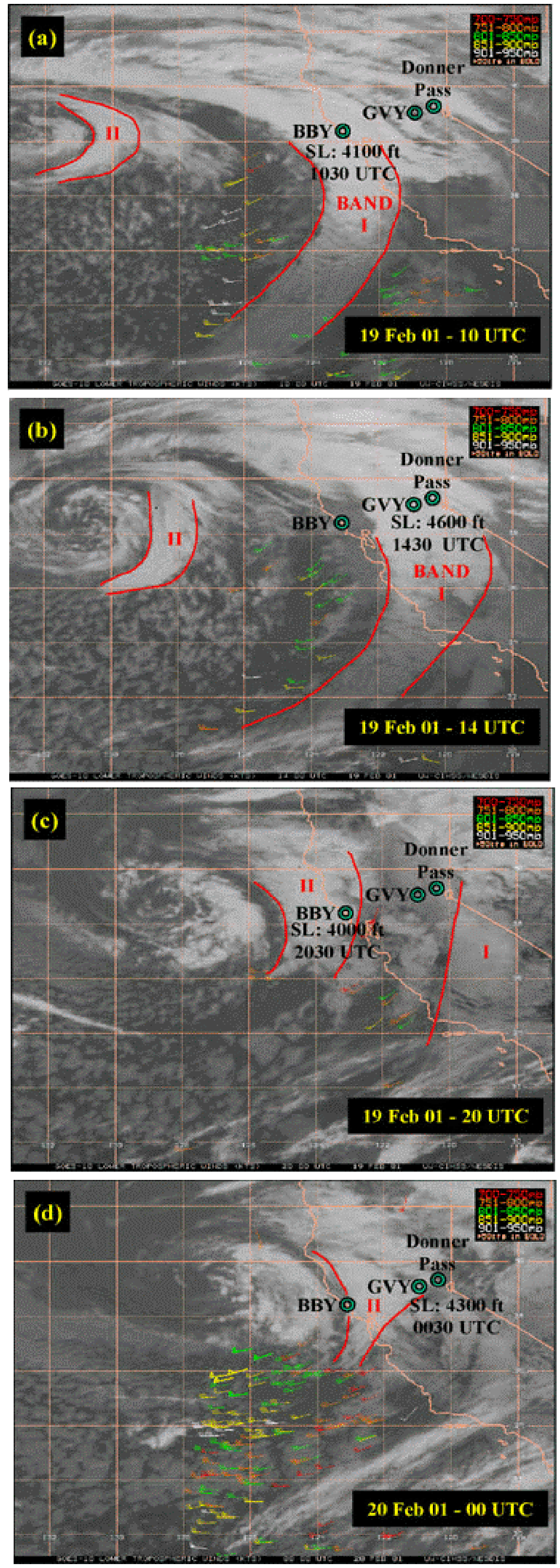


**Figure 3**. Satellite images showing two primary bands passing through California on 19-20 February 2001.

Bay, and the first snow level measurement in this storm was made (4,149 feet MSL; Figure 4a). The precipitation band reached Grass Valley at about 1430 UTC, where a snow level of 4,591 feet MSL was observed (Figures 3b, 4b). The snow levels at the two sites were similar, and the BBY data provided a four hour lead time before the precipitation hit Grass Valley on the western slopes of the Sierra, 50 miles west of Donner Summit. The second band hit BBY by about 2030 UTC, with a snow-level of 3,962 feet MSL (Figures 3c, 4a), roughly four hours before reaching GVY where the snow level was found at 4,345 feet MSL (Figures 3d, 4b).

Although not all storms will have a signal as clean as seen in this case, this example illustrates the concept that will be thoroughly explored. It shows that the snow level at BBY matched within roughly 400 feet of what was observed four hours later near Donner summit.

The snow levels recorded during this case study were relatively low and provided a four hour lead time from the time the frontal bands hit the coast of California to the time they reached the western edge of the Sierra at Grass Valley. Other cases analyzed were not as fast moving and provided greater lead times (10-12 hours) and also provided rain versus snow timing at

Donner Summit. These cases will be presented at the conference and details can also be found at the web site http://www.weatherextreme.com/NSAA.html under the AMS Annual Meeting 2003 link.

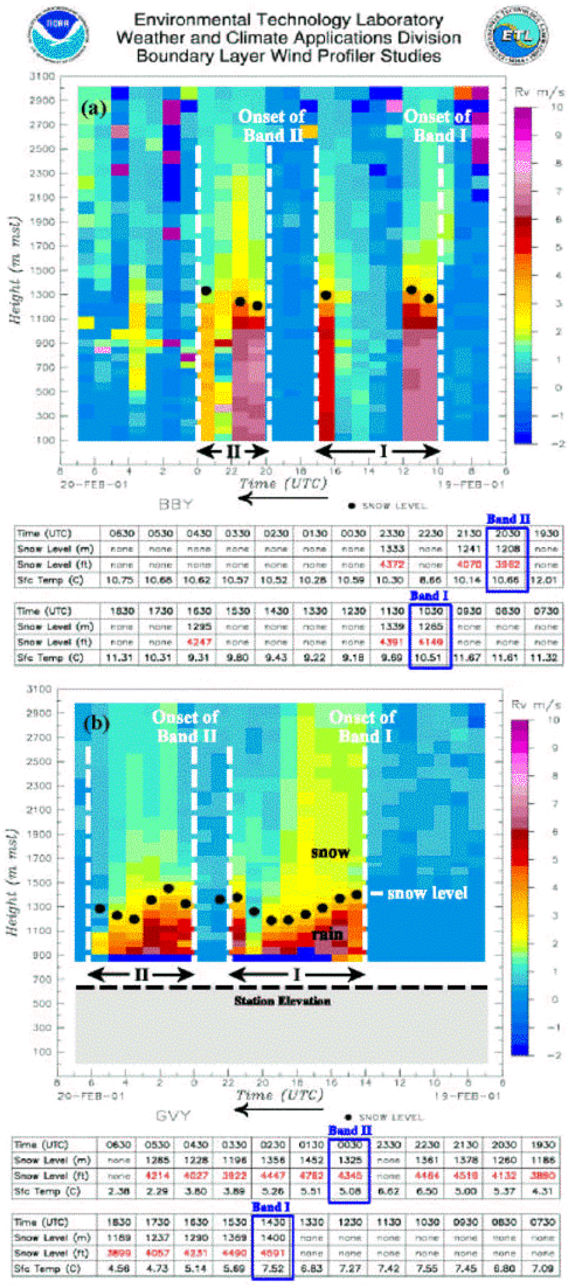


**Figure 4.** Snow level information from the NOAA/ETL wind profilers at Bodega Bay (a-upper) and Grass Valley (b-lower) from 19-20 February 2001.

## 4. IMPACT ON TRANSPORTATION OPERATIONS

It is anticipated that during the winters of 2002/03 and 2003/04 a specialized field study will be conducted using profilers sited to optimize the potential application to highway operations on I-80 in the California Department of Transportation's (CalTrans) District 3 region. This will involve the interaction directly with the appropriate CalTrans officials, the contractors they use for specialized weather guidance, and the National Weather Service (NWS) that provides the base weather information. This project will also involve interaction with the Lake Tahoe and Reno Tourism Offices and the Nevada Highway Department to assess and address their needs.

During the winter of 2001-2002, Cal Trans expended $13Million in snow removal operations in District 3 (Mr. Mark Dinger, Public Information Officer, Cal Trans, personal communication). The total acreage of Interstate 80 within CalTrans District 3 affected by snow falling at different levels was investigated. Assuming $8,400 per lane per mile and there are eight lanes (including the shoulders) this amounts to $67,200 per mile per plowing months (October through May). Table 1 shows the cost to plow I-80 versus snow level. For example, if all snow fell at 6,000 feet during the winter months than the cost to plow I-80 in District 3 would be $1,250,000 from October – May. If all snow fell at a level of 3,000 feet than it would cost CalTrans $4,170,000 to plow I-80 from October – May. The biggest increase in plowing costs in District 3 occurs when the snow level goes from 6,000 feet to 5,000 feet at an increase in cost of approximately $2.2Million for the year.

| Snow Level | I-80 miles affected (centerline miles) | Cost to plow road (annual) | Cost Increase |
|---|---|---|---|
| 7000 feet | 4.2 | $280,000 | |
| 6000 feet | 18.6 | $1,250,000 | $970,000 |
| 5000 feet | 51.1 | $3,430,000 | $2,180,000 |
| 4000 feet | 55.6 | $3,730,000 | $300,000 |
| 3000 feet | 62.1 | $4,170,000 | $440,000 |
| 2000 feet | 77.9 | $5,240,000 | $1,070,000 |

**Table 1.** Annual cost of snow removal on I-80 in CalTans District 3.

If approximately one storm occurs every five days on average during the plowing months then we can assume about 46 plow days during a typical season. This amounts to a cost of $27,000 per storm if the snow level is 6,000 feet and a cost of $75,000 to plow a storm if the snow level occurs at is 5,000 feet. This means a cost savings of $48,000 if the snow level is accurately forecast at 6,000 feet. This exemplifies the importance of accurate snow level forecasts.

## 5. CONCLUSIONS

These examples explored only direct costs to the California Department of Transportation. During the specialized studies to be performed, other impacts such as public perception on snow level and the effect on the Lake Tahoe economy in terms of cancellations and ski resort visits will be analyzed. There is also tremendous pressure on CalTrans to keep I-80 open as it is a major thoroughfare not only for the traveling public but also for trucking companies.

During the 2000-2001 winter season the California Department of Transportation spent $13 Million dollars on snow removal for the I-80 region of California. An incorrect snow level forecast (either too high or too low) causes a great loss in monies through such items as overtime pay, improper staffing, and not enough equipment in the proper road regions. With more accurate timing of events as well as more accurate snow levels, CalTrans will be more effective in the amount of staffing they require, where to concentrate their efforts, what resources to use, and also in dealing with the general public in terms of possible road closures or road holds.

The wind-profiler derived snow level monitoring system has a direct impact on the plowing operations at CalTrans, the traveling public, water supply forecasts, and recreation (skiing, snowmobiling, boating). The goal of this study will be to integrate the results from science, user interactions, and field demonstrations to summarize the potential of these new data and concepts to improve highway snow maintenance and reduce adverse impacts on tourism.

**6. REFERENCES**


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