STEPS TOWARD COMPUTER-AIDED SNOW SAFETY

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ABSTRACT

Applications of small computers in snow safety and avalanche forecasting can be divided into categories like (a) compiling weather and snowpack history, (b) on-line data acquisition and (c) real-time analysis. As an example of real-time analysis, this paper describes a program that combines overnight snowfall and wind speed data with a file of slidepath topography to point out starting zones most likely wind-loaded.

BEGINNINGS

Most personnel responsible for present-day snow safety or avalanche control programs have witnessed the entire development of small, or personal computers, from crude scientific toys to the boxes of desktop magic that perform so much of what we call work, today. Throughout this transformation, a few snow-safety specialists have struggled to enlist these machines as avalanche forecasting aids. This paper briefly traces some of their efforts, and provides a new example, with the objective of showing how we've begun, and how we might arrive at computer-aided snow safety.

Back in 1975, before "microprocessor" was a household word, before these tiny silicone chips invaded almost every item of electronics in our homes, Gary Poulson built a Heathkit* model H8 computer and began to use it in his job as Snow Ranger (USDA Forest Service) at Jackson Hole ski area in Wyoming, U.S.A. With programming help from Jim Olsen (now with the U.S. Park Service), Poulson began compiling the weather and avalanche control data for Jackson Hole into disk files on the H8. Each morning that avalanche control work was required on the ski area, the computer searched these files to identify previous days with closely matching weather conditions (temperature, wind speed and direction, old snow surface, new snow available for transport). Results of control work on these similar days were presented by the computer from corresponding disk files. To this, Poulson added his interpretation for briefing the avalanche control teams during their early-morning tram ride. At this writing, data for 944 days form the data

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base, and the H8 has been replaced with an Apple Macintosh II (Gary Poulson, personal communication, 28 September 1988). The same program is being written on an IBM PC by the Wyoming Highway Department to aid control on Teton Pass.

The Jackson Hole example demonstrates two factors common to many successful applications of small computers: (1) the specialist became computer "literate", and (2) a professional programmer helped. Being computer literate means the snow safety specialist knows the working parts of a computer, how to operate the system, and has some idea of what this tool can do. Writing programs that make a computer help a specialist is not included in this sort of literacy--that's a programmer's job. (Some specialists, of course, become excellent programmers.)

Most applications of small computers in snow safety can be grouped into three categories: (a) on-line data acquisition, (b) storing historical records, and (c) data analysis. For on-line acquisition, a desktop computer is connected, often through a data logger, to sensors that measure weather and snow parameters, reducing or eliminating data-entry by the human finger. Record storage forms the data bases upon which some analysis programs operate, like Poulson and Olsen's program to search for similar days. At the high, and perhaps distant, end of the data analysis scale are "expert systems" which attempt to mimic some of the specialist's decision-making process, through artificial intelligence.

Systems in which measurements accumulated by data loggers are transferred over telephone lines or by radio link to a desktop computer on the snow safety officer's desk are becoming reliable aids that greatly speed accumulation and storage of data for snow safety decisions. One of the first such system, tested in 1982 by Arnold Ozment (USDA Forest Service, Ft. Collins, CO), linked a Campbell Scientific weather station and an Apple II Plus by phone lines. Chuck Tolton, at Copper Mountain, Colorado, was among the first (early 1980's) to apply modern data loggers to the snow safety problem. Data loggers are now used at Snowmass, Copper Mountain, Vail, and several other areas, but most are not yet connected to computers for on-line data acquisition. However, at this ISSW meeting, Hans Gubler reports on a system of data loggers radio-linked to a computer that monitors snow and avalanche data near his institute in Switzerland, and here at Whistler, Kel Fenwick has assembled a similar network that reports every 15 min to a desktop computer, to aid ski area operations.

An analysis application similar to that Poulson and Olsen developed was given the name "nearest neighbours" forecasting by Buser (1983) at the Swiss Federal Institute for Snow and Avalanche Research. This work continues as an operational forecasting procedure in Switzerland. Snowbird ski area in Utah has begun using nearest neighbor forecasting. At Alpine Meadows, records are assembled in a data base, but a forecast program is not yet written. Orographic precipitation forecasting, developed from Rhea's (1977) work, was programmed by the Colorado Avalanche Warning Center about 1980, originally on an Apple II Plus computer. Similar programs are now used by other large-area warning centers (on newer machines, yes?).

Now, finally, believing that analysis applications hold the greatest potential to improve snow safety with computers, we offer another small step in that category. On to "expert systems"!

PREDICTION OF PATH LOADING BY DRIFTING

Earlier papers by Hartman (1984), and Schmidt and Hartman (1986) showed measurements of avalanche loading from drifting snow, and a method of predicting such loading. While these calculations are not complicated, they are time-consuming when many paths are considered, and they must be done before control teams are dispatched, if benefits are to be maximized. The next logical step was to develop a computer routine that accomplished the analysis quickly, with a minimum of attention from the Snow Safety Director.

First we developed a slide path data base, containing (1) path identification number, (2) path name, and (3) wind direction for maximum loading efficiency. This direction was determined from topographic maps, and adjusted based on experience. A spreadsheet format, such as that produced by Lotus 1-2-3 is convenient for this step. Our procedure used array and string files that could be called from a program written in BASIC.

The first analysis program asked only for an average wind direction during the snow drifting event. Given this azimuth, it ran through the list of paths, seeking those with maximum loading direction within 20 degrees of the actual drifting azimuth. When a path met this criterion, a loading efficiency was computed. Efficiency was 100% if the wind angle matched the maximum loading azimuth listed in the data base. For each degree difference between wind direction and maximum loading azimuth, estimated loading efficiency was reduced 5%, as a first approximation.

At this point in the development, we stopped to test the usefulness of this very simple system. Given only a mean drifting wind direction, the computer selects from a 3-column data base those paths likely to be wind loaded, and computes the relative loading, based on the deviation of wind direction from each path's maximum loading azimuth. A printout of results (Figure 1) groups paths by control route, and provides room for remarks noted by the control team, to help improve prediction accuracy. A computer is not necessary for real-time analysis at this level of development. By making a printout for each 10-degree wind azimuth, copies of the printout for computations closest to the measured direction can be used. This proved very useful, but much more can be done with real-time computer analysis.

Adding one column in the data base, a loading efficiency/wind angle deviation can be assigned to each path, in place of the 5% per degree assumed for all paths in the first approximation. Adding another column for contributing distance (see Schmidt and Hartman, 1986) and entering snowfall available for relocation by wind allows estimates of drift volumes which are multiplied by the loading efficiency to predict actual snow volumes in starting zones. Another column containing starting zone distances along the wind direction yields estimates of new snow depth in each path, from loading volumes, by assuming deposition density.

SUMMARY

Building snow safety data bases, connecting computers to weather and snow sensors through data loggers, and obtaining real-time analysis of data, such as nearest neighbor sorting, are applications of the desktop computer that have already proved effective in snow safety programs. This paper suggests

PATH LOAD TABLE--AVERAGE AZIMUTH 220 deg DATE:____________

CONTROL ROUTE	ID#	PATH NAME	DIR	EFF	REMARKS
ALPINE I	136	BOUNDARYG.	225	75	______
ALPINE II	262	HEADWALLE.2	201	5	______
ALPINE III	325	ROBERTOS	226	70	______
	322	RAMP	234	30	______
	112	ALPINECLIFFSU.	217	85	______
	277	IMPOSSIBLEB.	225	75	______
	106	ALPINECLIFFSL.	238	10	______
	319	POSSIBLEBASIN	223	85	______
	313	PITCHVALLEY	217	85	______
	172	CASTLEGLADES	232	40	______
ALPINE IV	334	SHIPSPROW	221	95	______
	286	LADDERUPPER	212	60	______
	283	LADDERLOWER	238	10	______
ALPINE V	247	H.V.RIDGE	236	20	______
	358	WALL1	234	30	______
	169	CASSIDY	238	10	______
	349	UNION1	235	25	______
	352	UNION2	214	70	______
	130	BLACKSAT.BOWL	223	85	______
	217	GLADE1	221	95	______
	220	GLADE2	225	75	______
	223	GLADE3	231	45	______
BURN I	115	AMF	239	5	______
	178	GOWDYC.	237	15	______
	241	HANGON	205	25	______
	202	ELEPHANTSN.	220	100	______
BURN II					
BURN III					
CIRQUE I	292	L.HEADWALL	215	75	______
ELK CAMP I	187	CRACKOASS	202	10	______
ELK CAMP II					
KNOB I					

Figure 1 An example of the computer-generated work sheet for a storm wind of 220 degrees.

another real-time analysis that is helpful in areas where drifting snow loads avalanches. Continued progress in applying computers to snow safety appears to depend on (1) increasing the computer literacy of personnel and (2) employing professional programmers to help with system development.

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