Glide Avalanche Forecasting

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INTRODUCTION

The forecasting of glide avalanches is particularly important when human life or structures are threatened. The best way to reduce the impact of such avalanches is by suitable controls. Control requires that closures are in effect during unstable periods and/or explosives are used to minimize any risks. However, gliding, and the stability of a glide slabs are not easy to predict rendering the control process a challenging task. Until recently it was thought that water had to be present for gliding to occur [McClung 1987]. However, a two year study showed that in 88% of the cases of gliding water was present at the snow ground interface; the other 12% were during cold periods [McClung 1990]. This, along with the fact that glide avalanches do not necessarily occur during storm cycles, leads to the conclusion that forecasters require more information if they are to make accurate forecasts.

It is generally agreed that rapid displacement of the snow pack occurs before glide avalanches [McClung 1987]. The physical measurement of displacements in the snow pack has been attempted in the field [Akitaya 1988, In der Gand 1966, Lackinger 1986] but all of these methods can only measure one avalanche cycle. Thus, unfortunately, the technology to provide forecasters with continuous glide monitoring throughout the a glide cycle season has not as yet been developed.

This paper presents a new approach which has the potential to measure snow motion throughout the winter season. The avalanche starting zone chosen was path #3.7 at Galena Pass, British Columbia. Path 3.7 is a southeast aspect with a vertical fall to the highway of 700 meters. The instrumentation was a sprung probe which tilts as the snow moves. Once the slope has avalanched the probe returns to an upright position ready to monitor the next avalanche cycle.

METHODOLOGY

The starting zone dimensions (Figure 1) are 75 meters wide by 250 meters long with a ground surface of grass throughout. The remote weather station, from which weather correlation's were taken, is located a short distance from the 3.7 start zone.

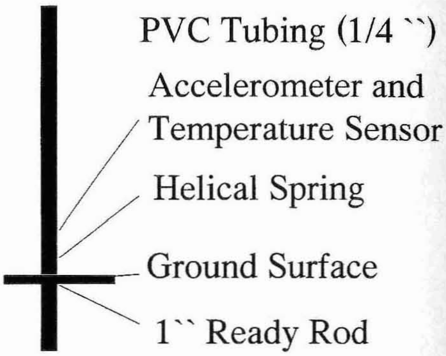

Figure 2. Schematic of the Probe used to measure tilt angles on the glide slope

Glide monitoring was achieved through sprung probes (Figure 2) mounted in the native ground surface of the avalanche starting zone. Three probes were installed in the 3.7 starting zone, in a downslope, inline array with 50 meters between each sensor (Figure 3). The probe located near the top of the slope was approximately 20 meters below the highest glide crack location. One inch threaded rod was grouted into the ground, and when the probe was

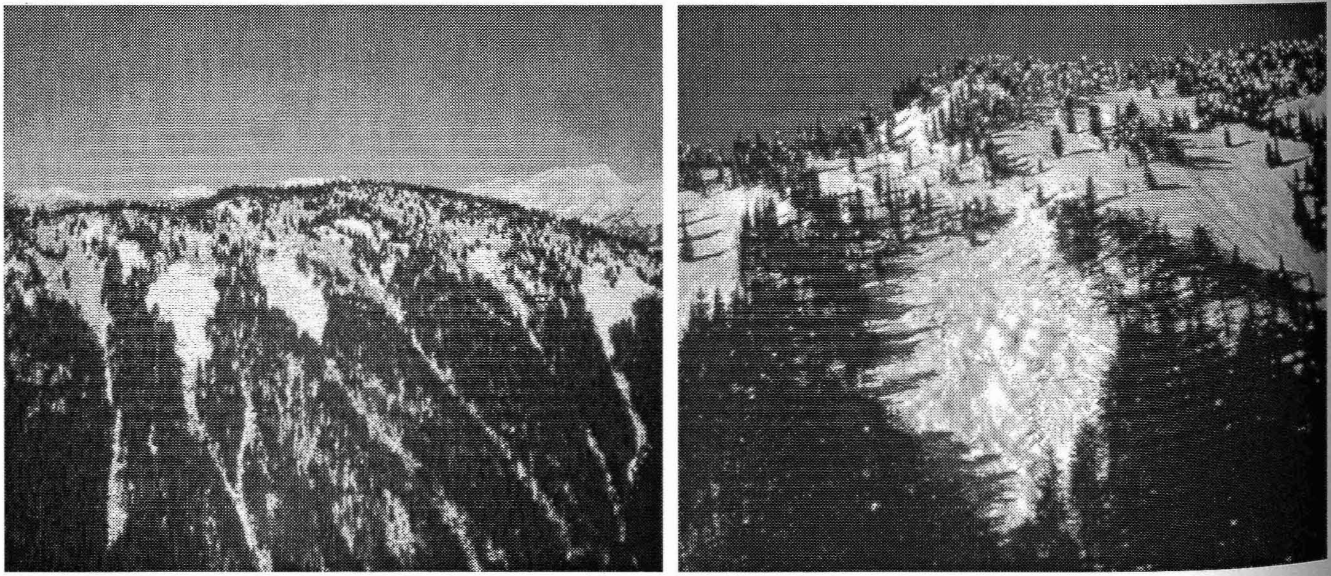

Figure 1: Glide Path 3.7 at Galena Pass, British Columbia.

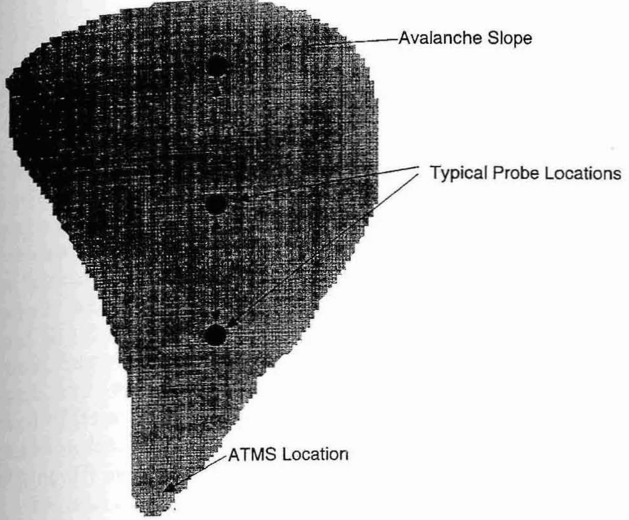

Figure 3. Probe Arrangement Used During Glide and Creep Monitoring.

screwed onto the rod the base of the spring was flush with the ground. Cables, hardwiring the probe to an adjacent data logger, were buried and data was collected by a Campbell Scientific 21X data logger at 10 minute intervals. The recorded data was downloaded daily via radio communications to Revelstoke, B.C. The data was recorded as a voltage whereupon a calibration was applied to convert the voltage into angles in an X and Y axis (Figure 4). During the second season of research an Avalanche Track Monitoring System (ATMS: Mountain Watch Inc. Alberta) was installed in the run out of 3.7 to determine exact avalanche occurrence times.

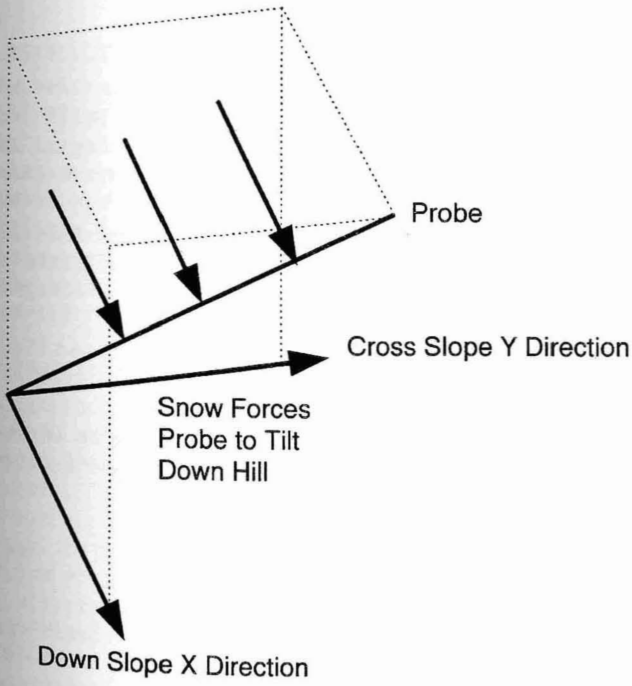

Figure 4. As the probe tilts there is a voltage change this is then converted into an X and Y tilt angle.

Snow pack movement was monitored by recording the tilt angle of the probe as it was pushed by the gliding snow. The probe (Figure 2) was designed to return to vertical after an avalanche event, as the return mechanism incorporated a coaxial steel spring with a protective sheath. The electronics were housed in a 1 m length of 25 mm diameter poly- vinyl-chloride (PVC) type 1 grade 1 UV stabilized plastic pipe. This material was sufficiently rigid for deflection measurements while remaining flexible enough to survive environmental conditions and avalanche events. The base of the entire probe was threaded to accept standard 1 inch coarse threaded rod (8 tpi). Two orthogonally mounted sensors were housed within the probe. The sensors used were solid state accelerometers, thermally compensated with a range of ±90 degrees in both longitudinal (down slope) and transverse (cross slope) directions. The tilt sensors had an accuracy resolution of ± 0.25 degrees. The electronics were sealed in moisture resistant thermoshrink within the probe. The probe was filled with Styrofoam insulation to limit thermal conductivity. Power was sourced from the data logger and each sensor required 12 VDC at 35mA excitation. The sensor package had a voltage regulator to govern power supply and excitation was pulsed on for minimum power consumption. Output signals were converted to a 0 to 20mA process loop current for immunity to noise, electrical shorts and independence of signal cable length influences. Voltages were collected and converted into tilt angles, where the sine of the tilt angle is a linear expression of the voltage output from the sensor.

RESULTS

The probes were pushed over by the snow as it crept and glided during the various cycles of the season. For each cycle there was a significant amount of motion prior to a release (Figure 5). After a release to ground, occurring during a glide avalanche, the probes generally returned to their vertical position. During the 1994/5 season one probe was ripped out of the ground and some major temperature effects were discovered towards the end of the season, and several several design improvements were made to improve the strength of the probes for the 1995/6 season. The 1995/96 season showed that these design modifications regarding the temperature compensation had been effective. However, since there were no glide releases the strength of the probes was not tested and by the middle of February the probes were pushed flat. Prior to February most events and all glide cycles were recorded by the probes. When retrieved in April 1996 two of the probes had been pushed down onto rocks in the ground,the plastic tubing bent and the springs stretched beyond there elastic limit.

CONCLUSIONS

The results show that the probes can monitor snow movement prior to an avalanche release and they stand a reasonable probability of surviving the season and several avalanche cycles. This method has the advantage over

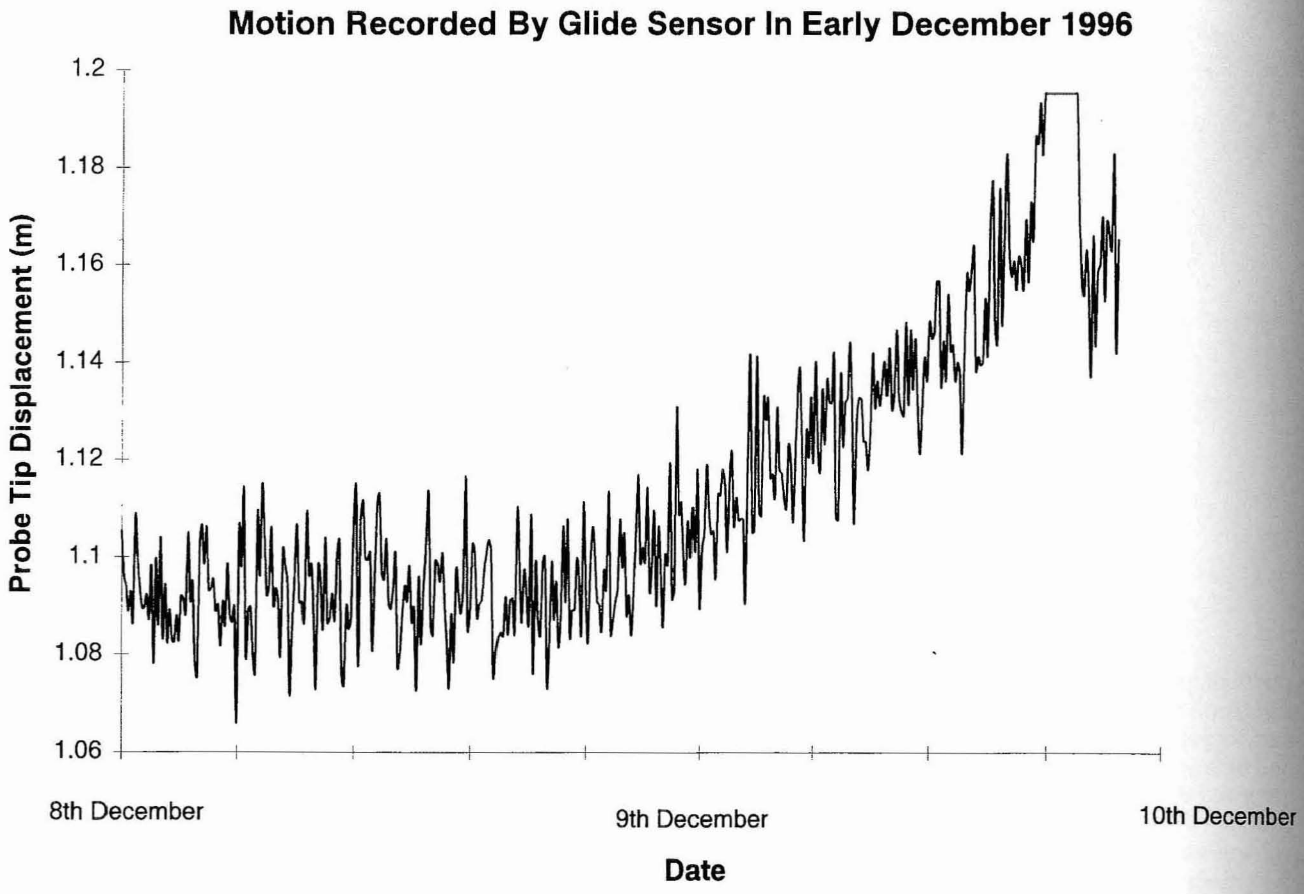

Figure 5: Typical displacement data obtained just prior to a glide creep avalanche cycle: This slab was heli bombed on december 11th.

glide shoes as the probes can be used repeatedly without access to the site. The biggest problem with this system is that if there are no glide slab releases there is no opportunity for the probes to return to the vertical position. Although, in this study no effort has been made to separate glide from normal avalanches such differentiation could be attained by using shorter probes. In future studies correlations with weather activity will be made, this was made difficult with this data set as the exact times of the recorded avalanches was not known in many instances. Further design improvements are necessary such as improving robustness of the electrical connections and probes themselves. Despite the limitations, the probes can provide the forecaster with additional information about glide cycles and creep in the snow.

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