EVALUATION OF AVATECH SP2 FOR SNOW RESEARCH AND SNOW SCIENCE EDUCATION

Hans-Peter Marshall1*

1Cryosphere Geophysics And Remote Sensing (CryoGARS) Group, Boise State University

ABSTRACT: This poster presents results from preliminary testing of the AvaTech SP2 for snow research and snow science education. The SP2 was used during a graduate Snow Physics course that contained a significant field component, and was compared with SnowMicroPenetrometer (SMP) profiles. The SMP was used to evaluate the SP2's ability to resolve important stratigraphic changes. The SnowMicroPenetrometer is an instrument that has been used by scientists for over a decade and has sub-mm depth accuracy, but is much heavier and an order of magnitude more expensive than the SP2. The SP2 shows great potential as a light-weight penetrometer for resolving snow hardness, and the ability to make measurements over large distances in challenging terrain is illustrated with 80 SP2 profiles that were performed in one day over a large elevation range in the Selkirk Mountains. More work is required to provide important uncertainty estimates on SP2 measurements in a wide range of conditions, and there are still some engineering challenges that need to be resolved, before this novel and exciting instrument becomes an operational tool.

KEYWORDS: instrumentation, penetrometer, hardness

1. INTRODUCTION

Most forecasting operations around the world base their assessment of snowpack stability on manual snowpack profiles and stability tests as well as on observations of avalanche activity and weather. In Switzerland, the rutschblock test (RB) is currently the preferred stability test, while in the U.S., the extended column test (ECT) has recently become the preferred stability test. The snow properties and the stability test result, which is an index of snow stability for skier triggering, are the most important parameters for the assessment of current snowpack conditions, an important basis for forecasting the regional avalanche danger.

Schweizer and Jamieson (2003) and Schweizer et al. (2007, 2008) showed the significance of observed snow properties at failure interfaces with respect to snowpack stability. Winkler and Schweizer (2009) and Schweizer and Jamieson (2010) analyzed the performance of different stability tests where the rutschblock test (RB) and the extended column test (ECT) are more reliable in predicting snowpack instabilities than the compression test (CT).

The assessment of snowpack stability from an automated, objective snow probe has been the objective of several studies during the last decade. The SnowMicroPen (SMP), a high-resolution automated penetrometer for snow, which measures penetration resistance or snow hardness at the grain scale (Schneebeli and Johnson, 1998), was mostly used in these attempts. The location of layer boundaries estimated by the SMP has shown to be very accurate when compared with manual observations (Pielmeier, 2003) and other tools such as radar (Marshall et al., 2007), however the measurements also provide microstructural information.

The physical theory to characterize snow properties from the SMP signal was first developed by Johnson and Schneebeli (1999). It describes three basic micro-structural parameters: the structural element length (L), the deflection at rupture (d) and the rupture force (F). From these, mechanical parameters can be derived, which can be related to stability. In the following years, Sturm et al. (2004), Marshall (2006) and Marshall and Johnson (2009) improved the theory, increasing the accuracy of the micro-structural and micro-mechanical estimates. Further improvements to signal interpretation were made by Lowe and van Herwijnen (2012)

Pielmeier and Schweizer (2007), and Pielmeier et al. (2006) applied the 1999 and 2006 versions of the theory in statistical approaches to predict the stability of known RB failure interfaces from the SMP signal. The classification accuracies were between 65% and 70%. Bellaire et al.
(2009) introduced a statistical approach based on Johnson and Schneebeli (1999) that yields 75% classification accuracy to predict the stability of RB and CT failure interfaces. Pielmeier and Marshall (2009) proposed a statistical classification model based on Marshall and Johnson (2009), where the best SMP parameter to predict RB stability was the micro-scale strength of the weak layer. When combined with the SMP-estimated mean density of the slab layer, the classification accuracy was 85%. They also showed that removing low quality SMP signals or increasing the number of SMP measurements at the RB scale improved the accuracy further.

While great progress has been made with the SMP, its cost, weight, and size, has prevented its widespread use, especially among practitioners. It remains the most accurate, destructive in-situ approach to measuring snow stratigraphy, and its use has expanded from the avalanche field to snow microstructure applications in snow remote sensing (e.g. Proksch et al., 2015). It is an extremely valuable snow research tool, but is not currently practical for practitioner use.

The AvaTech SP2 is a new portable snow penetrometer, which measures hardness variations in the snowpack. This new penetrometer was developed to provide information about snow stratigraphy with pressure measurements performed at the end of a small cone tip, while maintaining a small form factor and low cost.

This poster presentation highlights the use of the AvaTech SP2 in: 1) the field component of a Snow Physics course at Boise State University, 2) direct comparisons with the SMP, and 3) comparisons with standard in-situ observations. This new tool shows great promise, as it is highly portable and low cost. The depth accuracy is the largest remaining challenge, which if overcome, would allow the SP2 to be used to track snow stratigraphy for avalanche and snow remote sensing applications.

ACKNOWLEDGEMENTS

Avalanche provided SP2 instruments on loan at no cost for this work. The author was not compensated for any of this work, aside from access to the instrument and analysis/control software. The authors thanks Alex Merienthal for contributing data to this evaluation, Steve Conger and Tannis Dankin for support at the Sorcerer Lodge, B.C., and the students of GEOPH 566: Snow and Ice Physics at Boise State University during Spring 2016 for field assistance.

REFERENCES


