A COMPARISON OF THE SPATIAL PATTERNS OF PENETRATION RESISTANCE OF SLABS AND WEAK LAYERS

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Extended Abstract

Several studies have quantified the spatial variability of snow stability and structure on specific slopes. One consequence of such variability is that using individual point stability measurements to assess slope stability is questionable unless the variability exists in typical, and predictable, spatial patterns. This research examines the spatial patterns of the penetration resistance of a number of unique snowpack layers using the method of *universal kriging*, a common geostatistical technique. This two-step process first analyzes the data for spatial trends at the slope scale, and then uses semivariograms to quantify the spatial patterns of the residuals. Our data come from arrays of SnowMicroPen (SMP) measurements on small slopes in southwestern Montana and near Davos in eastern Switzerland. For a more complete and rigorous examination of this work, the reader is referred to Birkeland and Kronholm (*in preparation*).

Our goal was to see if predictable spatial patterns exist for layers with certain types of grains or deposited under certain meteorological conditions. Reliable extrapolation and interpolation of layer characteristics are possible only if such patterns exist. However, our analyses suggest that spatial patterns in penetration resistance do not depend on the layer grain type or on the conditions under which the layers were deposited. This is the case even for layers which form under relatively unique climatic conditions, such as surface hoar. In total, we sampled five different grids, four with surface hoar weak layers. Two of those four surface hoar layers demonstrated a significant linear trend at the scale of the study site; only one layer had an interpretable semivariogram. Of the 22 other layers we analyzed, a significant linear trend existed for 11 (50%) of them and data from 13 of the 19 layers (59%) resulted in interpretable semivariograms. Though we do not have enough data to make concrete conclusions, our semivariogram analyses suggest that layers at specific sites may have similar ranges. These variations do not appear to result from wind exposure since the layers from one sheltered site had relatively low ranges (1 to 2.5 m) while layers from another protected site only 100 m away that was sampled two years earlier had 6 to 8 m ranges. One possibility is that the sampling grids used at each site partially determined the range. We tested this hypothesis by removing some data from our analysis of a surface hoar layer and found that removing those data changes the apparent range from around 5 m to over 15 m.

In essence, the spatial pattern for each layer appears to be unique. Some layers exhibit spatial structure, while others do not at the scale of our measurements and analyses. These results emphasize the complexity of analyzing the spatial variability found on slopes, the difficulties in interpolating between point measurements, and the problems associated with scaling point measurements of snowpack parameters like stability up to the slope scale. Our results suggest that avalanche assessments will continue to be holistic, relying on expert human knowledge of specific slopes supplemented by a variety of additional data.

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Acknowledgements

We gratefully acknowledge Eric Lutz and Spencer Logan for collecting SMP data and providing important input and discussion, and Chris Landry for organizing some field days. This work was funded in part through a grant from the National Science Foundation Geography and Regional Science Program (BCS-0240310; K. Hansen, PI).

References

Birkeland, K.W. and K. Kronholm. In preparation. Spatial patterns of snow layer characteristics. To be submitted to *J. Glac*.