

SNOW SLOPE STABILITY MODELING OF DIRECT-ACTION AVALANCHES IN A CONTINENTAL CLIMATE: RED MOUNTAIN PASS, COLORADO

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ABSTRACT: Direct-action, or storm related avalanches occur due to rapid loading during snowfall. Previous studies have shown that a simple snow slope stability model (SNOSS) can give insight into the timing of direct-action avalanches in maritime environments. While modeling the evolution of the strength of buried weak layers is extremely difficult, estimating the evolution of strength of new snow due to densification can be much less problematic. To investigate the potential for applying SNOSS to direct-action avalanches in continental climates, we present results of model runs for the winter 2007-08 on Red Mountain Pass in the San Juan Mountains of Colorado, and compare these results to detailed avalanche observations.

KEYWORDS: snow stability, snowpack modeling, avalanche forecasting

1. INTRODUCTION

The SNOw Slope Stability Model (SNOSS) is a one dimensional slope stability model which compares the overburden stress to an estimate of the strength at equally spaced depths below the snow surface (Conway and Wilbour, 1999). The model uses an initial density estimated from the air temperature and a non-linear viscous fluid model (e.g. Marshall et. al., 1999) to describe the densification process. Strength is estimated from the density at a given depth, and compared to the shear stress caused by the weight of the overlying snow.

This strength estimate assumes constructive metamorphism through densification, and would not be applicable to surface hoar and other buried weak layers. SNOSS was developed to predict direct-action, storm related avalanches, and has previously only been tested in the maritime climates of Washington and New Zealand

. In this study we attempt to apply this model in a continental climate, with the goal of testing its applicability to direct-action avalanches in a very different snowpack.

2. PRELIMINARY RESULTS

As a preliminary step towards developing SNOSS for use in a continental climate, we focus on data during 22 days during the winter of 2008, during which a large avalanche cycle occurred that caused many naturally released avalanches on Red Mountain Pass, Colorado.

We begin by focusing only on naturally released avalanches on the Blue Point slide path on Red Mountain Pass, as this site is known to have frequent storm-related avalanches, and is the closest slide path to the Center for Snow and Avalanche Studies' (CSAS) Swamp Angel Study Plot (SASP). This weather station data is of extremely high quality, and includes hourly precipitation, which is a necessary input for SNOSS.

Figure 1 shows the air temperature record for the 22-day period, with a gray shaded area during which the Blue Point slide released naturally 3 separate times. The air temperature at

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SASP remains below zero throughout this unstable period, therefore these slides are unlikely to have released because of warm temperatures.

Figure 2 shows the record of hourly precipitation on the top panel, and the precipitation rate in the bottom panel during this period. The unstable period is shown again in gray. Note that the largest amount of hourly precipitation occurred during the unstable period, as well as one of the highest precipitation rates. However, due to digitization effects, the unstable period may be difficult to accurately detect, as it is only one measurement step away from stable periods.

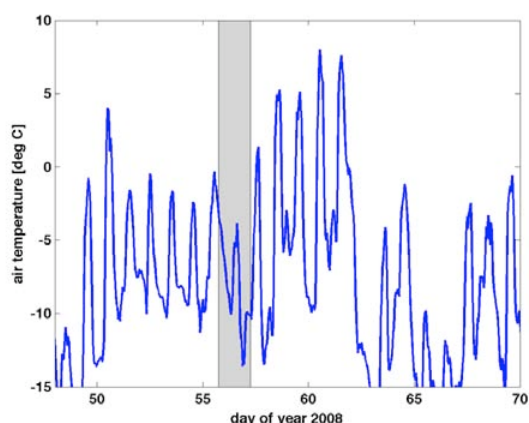


Figure 1: Temperature at SASP during Winter 2008. The gray shaded region shows the time during which 3 natural avalanches released at the nearby Blue Point slide path.

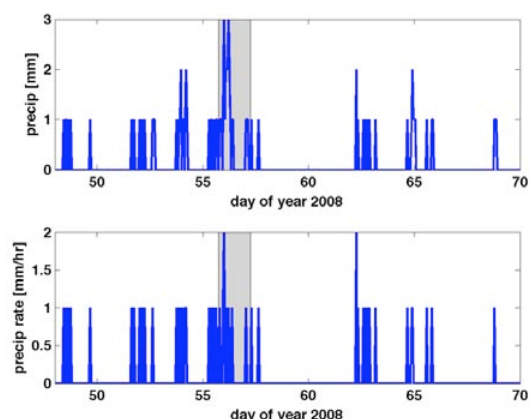


Figure 2: Hourly precipitation and precipitation rate during Winter 2008. Gray shaded region shows the same unstable period as in Figure 1.

The stability index is defined as the estimated shear strength (based on modelled density)

divided by the estimated shear stress (based on the cumulative precipitation above). It is calculated every 0.5 cm throughout the snowpack. Figure 3 shows the SNOSS stability index during the 22 day period. Note that there is a distinct local minimum in the stability index right during the unstable period, and that the later storm (~ day 62) which showed nearly as large hourly precipitation and the same precipitation rate as the unstable time, has a much larger stability index. This is likely due to the strengthening that occurred in the storm snow between days 58 and 62.

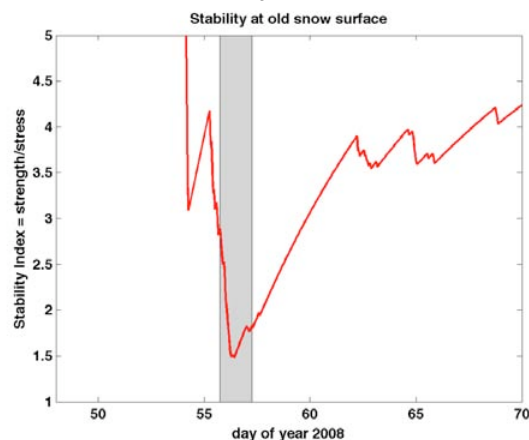


Figure 3: SNOSS stability index calculated at the old snow surface, based on hourly temperature and precipitation measurements at SASP. The gray shaded area shows the time period when 3 avalanches released naturally at the nearby Blue Point slide path.

3. CONCLUSIONS

This preliminary study indicates that SNOSS may be applicable, possibly with some modifications, for predicting direct-action avalanches in continental climates as well as maritime climates. Many more avalanche cycles need to be tested, and this is the subject of future work. Other slide paths will be investigated, as well as artificially released avalanches.

6. REFERENCES

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