

Foundations of the The Slope or Nope (SløNø) Model at the Fire, Weather & Avalanche Center

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ABSTRACT: The Fire, Weather, & Avalanche Center recently began implementing a simplistic forecasting system called the Slope or Nope (SløNø) Model. The intended audience is winter recreationalists that travel on or under avalanche slopes, with particular concern for snowmobile users. Spatial variability, complexity, and lack of resources are problems in forecasting that call for a simplified system. This model recommends “Nope” for conditions when users should stay away from steep slopes (30 or more degrees) and “Slope” for conditions that should allow for safe travel on steep slopes. It is a general recommendation with no bias in risk adversity that also emphasizes the importance of the backcountry user making their own call on the spot based on conditions there. Both observations and weather forecasts are built into a system for the SløNø prediction along with piloting some new snowmobile field testing for avalanche safety.

1. INTRODUCTION

Enjoying the backcountry during winter can be a safe and worthwhile endeavor but we must beware of avalanche terrain. These places are characterized by a slope steep enough for a mass of snow to slide, a surface allowing it to slide, and something to trigger it. While snow is often stable enough for this not to happen, there are certain characteristics that increase the likelihood of instability. Avalanche forecasting attempts to predict this:

Definition: Avalanche forecasting is the prediction of current and future snow instability in space and time relative to a given triggering (deformation energy) level.

Goal: The goal of avalanche forecasting is to minimize the uncertainty about instability introduced by the temporal and spatial variability of the snow cover (including terrain influences), any incremental changes in snow and weather conditions and any variations in human perception and estimation (McClung 2000).

During fall of 2017, the Fire, Weather & Avalanche Center (www.FireWeatherAvalanche.org) began piloting the Slope or Nope (SløNø) Model in an effort to develop a simplistic indicator of snow stability to guide backcountry users about avalanche conditions. The model operates on a principle that the basic decision an individual and group must make in avalanche terrain, “Do I travel on or under that slope or not?” There are many factors that should contribute to that decision, but ultimately the call is made within the context of the information available to the decision maker. We seek to match the simplicity of this yes/no decision with a model that recommends “Nope” for conditions when users should stay away from steep slopes (30 or more degrees) and “Slope” for conditions that should allow for safe travel on steep slopes.

1.1 Audience

We are attempting to focus on winter recreationalists that travel on or under avalanche slopes, with particular concern for snow machine users. Today’s machines are allowing for more travel in avalanche terrain. Snowbikes and snowmobiles are a primary user group in our pilot area so we are focusing the model in a way that is particularly useful and simple for that group. However, the the SløNø prediction will apply to skiers, snowboarders, and climbers as well.

2. THE CASE FOR SIMPLICITY

Beyond the aforementioned simple approach to match the simple decision, there are also other reasons that simplicity is important in an avalanche prediction model.

2.1 Spatial Variability

It is commonly understood that spatial variability in the mountains accounts for distinctly different avalanche danger within short distances (Deems et al. 2016; McClung and Schaerer 2006; Prokop et al. 2013). Efforts to create reliable models are still hampered by this spatial variability problem among other factors (Gobiet et al. 2016). Even within a micro-geographic area in the mountains, stability can be dramatically different (Hagenmuller et al. 2016). In other words, you may be traveling on a slope that is stable and then find a markedly different condition moving onto another slope aspect or a few meters change in elevation. Even subtle terrain features like protruding rocks cause trigger points where snowpack is different from the rest of the slope (Igor et al. 2016). There is just too much uncertainty in the snow (Guyn 2016). In a state of unpredictability like this, detail-laden forecasts further convolute the situation.

For these reasons, the SløNø Model is a general forecast for an area where, because of spatial variability, we will emphasize the importance of the backcountry user making their own call on the spot based on conditions there. Efforts will be made to link users to educational resources for how to make decisions in the backcountry.

2.2 Confusion in Complexity

Recreationalists need a simple message in their decision making. There is often too much information available in avalanche situations which can cloud judgement and suppress good decision making (Guyn 2016). More complex scales and forecasts have been shown to add confusion to the audience (Eastern Research Group 2014; Schwartz 2010). The message should be simple and precise to reach the broader audience in an effective way.

Furthermore, while performing a motor skill like skiing or snowmobiling, there is a narrow cognitive capacity for the athlete, especially if they are novice (Wulf 2007). This is especially important to have a simple message for the range of maturity and intelligence of backcountry users while in the field. This Slope or Nope concept will set the tone for the decision to be made while performing recreation sport skills in a complex environment.

Also, a significant segment of backcountry users are teenagers and college age with less mature mental skills; a simplistic message would serve this crowd better. Significant use of marijuana and alcohol by backcountry users renders clouded judgement for some, giving further credence to the need for a simple message. While this negates our emphasis on spot decision making on the user end, it does provide a clear recommendation whereas a complex recommendation may get ignored in poor attentional focus scenario.

2.3 Limited Resources

Many mountain regions are lacking in resources--both instrumentation and expertise--for precise forecasting. Rather than abandoning an avalanche forecast, it is better to use some available inputs and expertise to still provide a recommendation to the public. A simple system allows for more compliance due to a bigger output bandwidth while also putting more onus on the user to make decisions. Other areas that have many resource experts and instrumentation in a relatively concentrated area can afford more fine-grained differentiation in a forecast. Even in these smaller areas, spatial variability can yield different conditions though (Hagenmuller et al. 2016).

There have been increasing efforts to objectify systems and move beyond danger scales (Muller et al. 2016). With limited resources, the model here is being developed in an effort to combine some existing data inputs along with information from observations by a few observers to create a simple output to inform backcountry user decisions. Yet, ultimately the individual must be the decision maker on the ground when resources are limited (Tart 2017).

3. COMPONENTS OF THE MODEL

The main focus of the model currently is low-entropy type data forms. In some regard, this is to match the

simplicity of the model, but in other regards higher-entropy-based data and algorithms (e.g. Monti, 2012) are yet to yield better results in forecasting, so keeping it simple still has merit.

3.1 Weather Forecasting

This model integrates past and current observations with impending weather. Our team of credentialed and proven meteorologists provide specific mountain forecasts which are a key element of the system. There is a movement toward forecasting in avalanche (Coleou et al. 2016) which is especially important since the backcountry user will likely be in terrain several hours past the examination of the current conditions or forecast. The SløNø Model has developed an index score under testing that informs the decision on *slope* or *nope* output currently employed.

3.2 Observational Omens

Important avalanche indicators such as observations of recent avalanches, collapsing, past snowfall, and wind are also heavily factored into the decision algorithm of the SløNø Model. Fitzgerald (2017) encourages focusing on simple things like wind and precipitation, along with listening to your inner voice. Other elements like threshold examination of snow profile characteristics (Igor 2013; Monti, 2012; Schweizer 2006) through examination in snow pits are included in determining stability in our model. However, the main emphasis is currently on low entropy data-types and more complexity will be added as it is proven to be effective.

3.3 Road Cut Tests

FWAC has initiated a new testing technique for snow stability that is a spin off of the Slope Cut Test (American Avalanche Association, 2016). It is geared toward snow machine users and aimed at collecting many tests on several slopes in a day's ride. Since snowmobilers usually ride roads as entry points to steeper terrain, this test samples a number of road cuts with sidehill slope cuts. This is a common practice in snowmobiling anyway, but the attempt is to standardize and record the road cuts as an indicator of stability.

The test protocol includes the following:

1. Snowmobiler or snowbiker, preferably with at least one other to observe.
2. The rider should find a safe slope on a standard vehicular (summer) road with a height of least 3 meters.
3. The rider should approach the slope at an angle near parallel to the road at a reasonable speed.
4. The rider should climb to at least 50 percent of the slope height, and travel along the slope for at least 3 meters before returning to the road surface.
5. The rider should attempt to cut as deep as possible into the snow with their track and ski.
6. An observer should watch for any avalanches from a safe location, noting the characteristic (e.g. slabs, loose) and any cracking or collapsing that is seen.

Results for an entire day are recorded as an RCT followed by (# of avalanches triggered) / (# of attempts) and notes.

Example:

- RCT 0/12 - Twelve tests on a snowmobile with no avalanches triggered.
- RCT 1/5 Soft Slab, Snowbike - Five RCT attempts on a snowbike with 1 avalanche triggered that was a soft slab
- RCT 2/5 Hard Slab - Two hard slab avalanches triggered in five tests.
- RCT 0/8 Collapse, crack - No avalanche results in eight tests but collapsing and cracking occurred.

The test provides the advantages of several samples with limited physical note taking. Users simply need to tally the number of RCTs throughout the ride and note any avalanches. In most cases, this can be a mentally noted, eliminating the need to stop and spend time writing in a field book. This should yield

better adherence by the gearhead group and provide some in-the-field data that is a practical and fun way to approach riding trails.

Slope Cut (SC) testing calls for the subject to cross a slope similar to a start zone for an avalanche. Typically snow machine users would not drop in from a ridge or mountain top to cross a start zone like a skier and test the slope. A snow machine user is usually climbing up to a start zone area or traversing across several potential start zones. During this process the machine is having much more impact on the snow, much more than they would if they were dropping off a ridge into start zone. So, the SC test on a snowmobile puts the user in greater danger if done in a way to mimic a real trigger event; if done in the manner of a ski cut test, it yields unrealistic behavior for a typical snowmobiler.

Since snowmobilers have the advantage of weight and power with them, they can afford to do several tests that provide heavy impact on the snow. This test promotes quantity of samples in a variety of locations, which may be more useful than a thorough test in one location, which is often done by skiers. The spatial variability problem demands more samples.

3.4 Other Stability Tests

Digging snow pits and performing standardized stability tests are important (Staples 2017). Our preferred stability test procedure is to perform two Extended Column Tests (ECT). Research by Techel et al. 2006 shows that more reliability can be obtained with 2 tests and this seems practical from a time standpoint (in comparison to doing a slightly more reliable Rutschblock). The ECT is also recommended by Birkeland (2017). However, most stability tests are developed in the context of human triggered avalanches by skiers with focus on the top ~120 cm of snowpack. We theorize that snow machines will penetrate deeper into the snowpack and produce different forces, vibrations, and angles of approach compared to a skier. Research by Thumlert and Jamieson (2013; 2014) showed similar impact forces in the snowpack by skier and snowmobiler, but this was done with a snowmobile travelling straight uphill over the test site (which appeared to be a moderate angle slope), with limited information presented on the type of machine or position of the rider. We applaud the effort to research snowmachine forces, but at this time there is a dearth of research on this subject. While we lack good standardized tests for snow machines, at the very least an ECT result may give an indicator of propensity to propagate.

One must always remember that tests are only useful if they reveal instability (McClung & Schaerer 2009). Failure of a test to initiate a result is not an automatic green light to enter avalanche terrain. As Tart (2017) states, let observations steer you toward more conservative choice, not the inverse. Or more precisely, field tests should be used to turn you around (if instability is found), rather than something that pushes you forward into avalanche terrain if no results are seen (Birkeland, 2017).

3.5 Bias

Some systems attempt to forecast for worst case scenario (Pike 2013; Samenow 2017) and others lean toward the more cautious end. Worst case scenarios are often used to show uncertainty to the public; however, it creates unintentional bias into forecasts (Nadav-Greenberg, Joslyn, & Taing 2008). We attempt to eliminate this type of bias in the SløNø Model. The *Slope/Nope* decision seeks to predict based on a hypothetical individual that is exactly in the middle of the imaginary scale of most risk averse to least risk averse. The “middle” approach is also recommended by Fitzgerald (2017).

3.6 Hindcasting

All of the aforementioned testing and variables are being collected in a dataset that will be used to test the effectiveness in an effort for ongoing improvements in the accuracy of the model. The index algorithm will see ongoing improvements as well from looking at predictions in comparison to actual occurrences.

4. DELIMITATIONS

While simplicity is important, there is an inherent problem in a dichotomous output of *slope* or *nope*. The parameters allow for no distinction of conditions that are close to the decision point of one or the other. In

other words, increasingly dangerous conditions may be occurring while the response is still a “go” message from the system. The user may be unaware of this. Even worse, a borderline situation that leads to a *slope* value could spur someone to charge onto a slope that avalanches and hurts or kills them. We believe forthrightness about revealing our “call” to the public overrides concern for making a mistake. As long time avalanche professional Liam Fitzgerald (2017) encouraged, do the best you can and know mistakes will happen. The reality is that avalanche forecasting is not a precise science and even in conditions with many resources and avalanche mitigation, like ski resorts, avalanche fatalities and injuries continue to happen. Furthermore, we should not assume that snow experts are expert decision makers in avalanche situations (Costa & Adams 2016). Expert forecasters know a lot, but they still make mistakes (Fitzgerald 2017; Nalli 2017; Staples, 2017; Tart 2017) and even get caught in avalanches themselves.

The big caveat in any avalanche forecast is the reality that the audience should always use caution in the backcountry. We have attempted to limit this shortcoming of the SløNø Model in two ways. One is to always emphasize the spatial variability problem and the need for users to assess conditions on the spot, at all times. The other control is to add a short verbal message along with every *Slope* or *Nope* output. This short message will focus the user on particular problems and situations that may be borderline.

Another way that the dichotomy problem is being addressed is by developing an index score. Over time as this is validated as reliable it is intended to be presented publicly along with the *slope* or *nope* response as an indicator of severity.

We argue that no forecast model is entirely accurate. Bair et al. (2016) have done well to show the lack of agreement in evidence supporting existing theories on avalanche release. Our collective knowledge of the avalanche phenomenon is still rudimentary--with even the most advanced systems relatively not much better--so our modelling should remain simplistic in the meantime.

5. FURTHER READING

- International Snow Science Workshop Papers
<http://arc.lib.montana.edu/snow-science/index.php?view=default>
- *Journal of Outdoor Recreation and Tourism*
<https://www.journals.elsevier.com/journal-of-outdoor-recreation-and-tourism/>
- *Cold Regions Science and Technology*
<https://www.journals.elsevier.com/cold-regions-science-and-technology>
- SWAG
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