

TWENTY-FIRST CENTURY AVALANCHE FORECASTING WITH TWENTY-FIRST CENTURY DATA AND METHODS

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Jack R. Rueppel

¹ Citizen Scientist¹, Breckenridge, Colorado, USA

² Career Avalanche Forecaster/Technician 43 years, Colorado USA

ABSTRACT: Spatial Avalanche forecasting using Twenty-First Century publicly available avalanche data is presented. After examination of almost 1000 avalanche accidents where snow travelers were caught, buried or killed new concepts and methods are introduced these include: spatial forecasting, tertiary normal, slab waveguides, collapse manifold, crux mirroring, volatile and inert snow identification, sinter period, spatial based avalanche forecasting and cumulative recent micro-scale travel. Avalanches are separated into two distinct physical and mathematical phenomena; shedding and deadly triggered avalanches. Temporal avalanche forecasting favored by the avalanche community and industry is appropriate only for Shedding, Angle of Repose, Multi-day storm avalanches. Deadly triggered avalanches are more appropriately forecast and avoided by Spatial means.

KEYWORDS: A.E., tertiary normal, slab waveguide, crux mirroring, collapse, sinter.

1. INTRODUCTION

Snow instability is inherent and always present in alpine snowpacks. In "The Avalanche Handbook" 4th edition Dr David McClung draws attention to changes to avalanche accident demographics in the 1980s worldwide. This is a change from shedding avalanches which pose a danger to infrastructure and those within to those killed hiking, climbing, skiing, snowboarding and snowmobiling hereafter referred to as snow traveler avalanches.

When 21st century avalanche fatality data in the United States is examined this demographic shift is not reflected in avalanche accident reporting and documentation, the avalanche danger scale, avalanche problems, avalanche awareness education and professional avalanche education.

Common practice forecasts avalanches from high entropy, temporal, weather information on macro and mezo-scale data. This is appropriate for direct action, angle of repose, shedding avalanches which are not the cause of 21st Century avalanche deaths in the United States.

2. NEW CONCEPTS

Proposes new concepts: spatial forecasting, tertiary normal, slab waveguides, crux mirroring, volatile and inert snow identification, sinter period, collapse manifold, recent cumulative micro scale travel and spatial based avalanche avoid-

ance.

3. SPATIAL FORECASTING

Micro scale forecasts are needed for safe snow travel. Avalanches in the 21st Century can be forecast on a micro scale from low entropy spatial signs and observations along with historic causality data regardless of alpha angle.

A Spatial Avalanche Danger rating is derived from site avalanche accident history, site avalanche observations, observed shooting cracks, collapse and whumphfs on approach or on site, crux mirroring snow instability tests(Rueppel, 2023), volatile snow identification, cumulative recent micro scale travel.

4. Tertiary Normal

Tertiary Normal is presently referred to as Fracture Line or Crown . In the order of events of avalanching the Tertiary Normal only becomes visible/apparent after it has been triggered in a persistent weak layer in the snow less than one meter deep(McCammon,2002) then critical and supercritical shear cracks spread often stepping out and down in snow depth.

Common practice is to refer to the Tertiary Normal as a vital component in understanding avalanches and is often referred to as the trigger point and where the avalanche "broke" when in fact it is the normal of the shear crack end. It is an avalanche boundary feature. It is an avalanche perimeter feature.

5. Slab Waveguides

The Persistent Weak Layer may be better understood as a Slab Waveguide. Lab studies of shear failure acoustic emissions verify acoustic

* Corresponding author address:

Jack Rueppel Box 7696 Breckenridge Colorado, 80424 USA;
tel: +1 970-485-3112; fax:
email: Jack4of5@gmail.com

emissions travel in the weak layer and not in the slab(Reiweger et al, 2013). When enough of the weak layer collapses slab bending becomes catastrophic and deadly avalanching.

6. Collapse Manifold

If collapse precedes shear(Heierli, 2011) the unseen/invisible part of the avalanche process is the most important component.

We can predict the collapse manifold within the alpha angle, during the sinter period, in anisotropic, heterogeneous, volatile areas.

Avalanche accident reporting and documentation classes by user activity such as hiking, climbing, skiing, snowboarding and snowmobiling. These are an often a subgroup of those on foot. Multiple snowmobilers getting unstuck, travelers jumping into slope, skiers retrieving a lost ski, grouped travelers en mass, snowshoers in the middle of a larger group, travelers ascending or descending on subsequent passes in the same area are the collapse manifold.

7. Crux Mirroring

Snow instability tests can be performed outside the alpha angle similar to the predicted collapse manifold.

8. Volatile and Inert snow identification

21st century avalanches are triggered in Volatile Areas where and when shallow slab waveguides coalesce as a collapse manifold in an anisotropic heterogeneous area.

Avalanche triggers may be anticipated where slab waveguides are less than one meter deep often in heterogeneous areas such as buried saplings, willows, long grasses that can be considered collapse features.

Inert Snow is characterized as deep or thick Isotropic homogeneous areas.

Common practice refers to these areas as starting zones.

9. Sinter Period

Anyone traveling through the area recently is at risk of deadly avalanching. The more travelers the area the more likely a tragic catastrophic event. Each additional traveler increases the size of the collapse manifold where slab bending transitions to brittle slab shear failure. It is only when the slab is in motion the avalanche becomes visible.

10. Spatial Based Avalanche Avoidance

Groups often gather in the Alpha Angle, this should be avoided(stuck snowmobile, lost ski).

Areas with a previous accident should be avoided(caught, buried, killed). Avalanche observations are seasonal signs possible return avalanches due to subsequent formation of shallow near surface facets, surface hoar, melt freeze crusts and ice lenses.

10. Temporal Forecasting

High or Extreme forecasts based on weather forecasts predict Shedding/ Angle of Repose avalanches and not deadly snow traveler triggered avalanches.

High or Extreme avalanche ratings account for little or no deadly avalanches.

Almost all fatal accidents occur under considerable low, or moderate avalanche ratings. It is the authors opinion travel plans and route choice are not influenced by a high or extreme forecasts and they are more a factor of poor trailhead access and snow traveler poor vision expected during multi-day storms.

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3.1. References

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