WIND SLAB OR STORM SLAB; WHEN DO WE USE EACH TERM?

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ABSTRACT: Though explicitly defined by the Conceptual Model of Avalanche Hazard (CMAH), the terms wind slab and storm slab are sometimes used interchangeably. Storm slabs and wind slabs exist on a continuum, and avalanche workers may disagree on which term is most accurate for a given situation. This discrepancy can cause miscommunications in the Canadian avalanche industry, where information sharing relies heavily on the CMAH. Inconsistency exists in public bulletins, and many avalanche professionals have debated the difference between these two avalanche problems with coworkers. However, the extent of inconsistency in professional communications has not been rigorously investigated. Using a sample of avalanche problems submitted to the Canadian Avalanche Association's Information Exchange (InfoEx), we found that nearly 20% of operations used the term storm slab to describe an aspect-dependent avalanche problem located on aspects lee to the prevailing wind direction, which could otherwise have been called a wind slab. This discrepancy may stem from whether preferential deposition of snow by wind is considered a storm slab or a wind slab. Additionally, some storm slab problems in the study period included a wind slab, as indicated in the associated comments. This project explores inconsistency in terminology use in the Canadian avalanche industry in order to promote further discussion and identify possible solutions to maintain consistency.

KEYWORDS: Wind slab, Storm slab, Terminology, Avalanche problems

1. INTRODUCTION

Avalanche forecasting operations in Canada regularly share data with each other, and avalanche workers often work at multiple different operations over their careers or even in the same season. This connectivity between operations is one of the reasons that the Canadian avalanche industry emphasizes consistency in terminology used in avalanche forecasting. Consistency is maintained in part by encouraging the use of the Conceptual Model of Avalanche Hazard (CMAH) (Statham, Haegeli, et al., 2018), which separates avalanche problems into nine distinct avalanche problem types. The CMAH is integrated into the information exchange (InfoEx) software maintained by the Canadian Avalanche Association (CAA), which allows for straightforward communication of important observations between nearby operations, and simplifies the movement of avalanche workers between operations.

Although most forecasting operations in Canada use the InfoEx and the CMAH, inconsistency still occurs in how terms are interpreted and applied (Hordowick, 2022). Forecasting inconsistencies have also been documented in the USA (Lazar et al., 2012) and Europe (Techel et al., 2018). Discrepancies may happen when forecasters disagree on which avalanche problem type is most appropriate for a given situation. Wind slab and storm slab are two problem types that are sometimes interpreted and applied interchangeably. Although avalanche problems are divided categorically for forecasting and communication purposes, in reality many avalanche problems exist on a continuum. This leads to different interpretations and opinions, and can make it difficult to choose a specific label for a current avalanche problem.

While previous studies have investigated terminology inconsistency in public bulletins, (eg. Hordowick, 2022; Klassen et al., 2013; Lazar et al., 2012; Statham, Holeczi, et al., 2018), our industry knows less about terminology inconsistency in professional communications. Colloquial knowledge tells us that the debate between wind slab and storm slab happens in a number of forecasting offices, yet the extent of this has not been quantified. While public perception and communication can influence terminology decisions for public forecasters (Hordowick, 2022), professional communications should be unbiased by this consideration. In this study we analyzed a sample of Canadian InfoEx submissions to determine the extent of inconsistencies in the professional use of the terms wind slab and storm slab. Understanding the extent of inconsistency is an

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important first step before the inconsistency can be addressed.

2. BACKGROUND

2.1 InfoEx

The InfoEx is a daily exchange of snow, avalanche, and weather information managed by the CAA and used by avalanche operations across Canada (Haegeli et al., 2014). This includes ski areas, highway programs, railway programs, consulting companies, mechanized guiding, and human-powered guiding. The exchange of information is confidential and provides a way for operations to candidly share important information and observations that may benefit neighbouring operations. It also provides extensive data for Avalanche Canada's public forecasters. The InfoEx contains a structured forecast workflow based on the CMAH. In 2003 the InfoEx moved from a fax-based subscription to a web-based portal (Haegeli et al., 2014). The InfoEx as we know it today, while designed as a communications tool, also acts as a database of past snow, weather, and avalanche information.

2.2 Public Bulletin Inconsistencies

Previous studies on terminology inconsistencies in the avalanche industry have focused on public bulletins. The emphasis on clear communication with the public could be the source of some variation in how avalanche problem types are applied in public bulletins (Hordowick, 2022). The nuances of public communication mean that public avalanche forecasting may look different in different places and at different times, and so terms may be used slightly differently. On the other hand, consistency between public bulletins is important so that members of the public understand the avalanche problem regardless of where or when they are travelling in the backcountry (Lazar et al., 2012). Striking a balance between these two priorities is a major challenge of public forecasting.

Recently, researchers found varying opinions between public forecasters on when they use a storm slab problem versus a wind slab problem (Hordowick, 2022). While all forecasters interviewed stated their minimum threshold wind speed for adding a wind slab problem was in the moderate range (26-40 km/h), their maximum allowed wind speeds for a storm slab problem varied from 10–60 km/h (Hordowick, 2022). This large range of wind speeds highlights individual and operational inconsistency. Determining exact wind speeds permitted for each problem type is especially difficult, since most winter storms include at least some wind, and wind slabs and storm slabs exist on a continuum. Hordowick (2022) also found a range of opinions on when and if these two problem types could be listed simultaneously. While some operations rarely used the term storm slab, others used it for most storm events, even if wind was present, and only added a wind slab problem later if necessary. Some forecasters may do this intentionally, in order to better describe the spatial variability of the problem and simplify communication with the public (Klassen et al., 2013). A variety of other rationalities, whether conscious or unconscious, may exist to explain why different forecasters use the terms wind slab and storm slab differently.

2.3 Definitions and Transport Processes

Although most winter storms include wind, the CMAH only considers wind in the definition of a wind slab, and not in the definition of a storm slab (Statham, Haegeli, et al., 2018). It describes a storm slab as a "cohesive slab of soft new snow" (p. 674), and a wind slab as a "cohesive slab of locally deep, wind-deposited snow" formed by "wind transport of falling snow or soft surface snow" (p. 675). Importantly, this explanation describes two different wind transport processes:

1. "Wind transport of … surface snow" describes redeposition, which occurs when snow that has been on the ground for a period of time is entrained by the wind, transported, and deposited elsewhere (Figure 1).

2. "Wind transport of falling snow" describes preferential deposition, which occurs when snow from the air column is deposited directly into a lee area without having previously touched the ground or undergone extensive saltation (Lehning et al., 2008) (Figure 1).

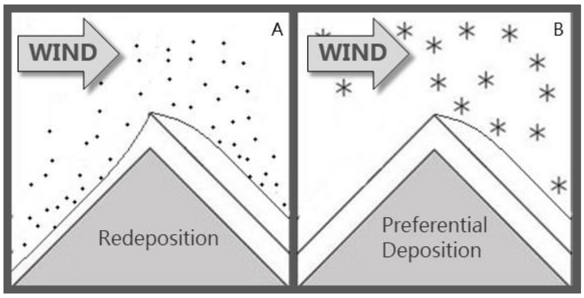

Figure 1 – Redeposition (a) occurs when snow already on the ground is transported. Preferential deposition (b) occurs when snow from the air column accumulates in a specific area due to wind.

According to the CMAH, both redeposition and preferential deposition result in a wind slab avalanche problem (Statham, Haegeli, et al., 2018). However, in practical situations, including preferential deposition in a storm slab problem may more succinctly describe current conditions, particularly if the problem is not obviously aspect-dependent (Klassen et al., 2013). This is akin to the new snow problem of the European Avalanche Warning Services (EAWS), which encompasses any avalanche problem related to recent or ongoing snowfall (European Avalanche Warning Services, 2023). The EAWS definition also allows a new snow problem to become more critical due to wind, while an EAWS wind slab problem only includes the redeposition of snow already on the ground. This is different from the model used in North America, where both redeposition and preferential deposition are grouped together under the term wind slab according to CMAH.

3. RESEARCH GOALS

The goal of this study is to investigate and understand the extent of inconsistency in the use of the terms storm slab and wind slab in professional communications unbiased by considerations of public perception. To do this, we analyzed a sample of InfoEx submissions to determine the prevalence of operations using the term storm slab to describe an avalanche problem formed by preferential deposition, which may otherwise have been described as a wind slab.

4. METHODS

We reviewed all storm slab problems submitted to the InfoEx in January of 2022, recorded the operation which submitted it, and classified each storm slab as either aspect-dependent or all-aspects (Figure 2). Aspect-dependent storm slabs were then labelled as preferential deposition only if the problem was located on aspects lee to the wind direction reported by that operation on that day. Comments associated with these storm slabs often emphasized the role of wind.

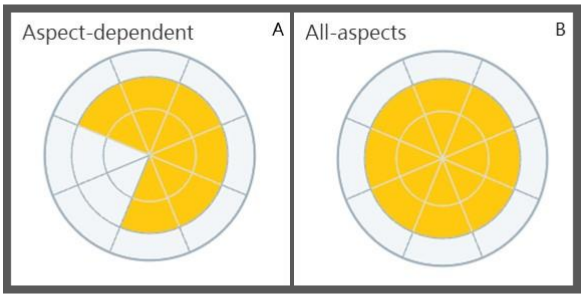

Figure 2 – InfoEx compass roses associated with aspect-dependent (a) and all-aspects storm slabs (b).

Additionally, many all-aspects storm slabs included a wind slab problem. This was determined from associated comments, which ranged from stating that the slab formed with wind, to explicitly stating that the problem included a wind slab. Some of these storm slabs also included additional avalanche problems such as dry loose or wet loose, but these were not included in this study. Any all-aspects storm slabs which included a wind slab were also recorded.

We chose the month of January as a sample period in order to minimize the chance of storm slab aspect-dependence caused by the influence of the sun. In the spring, increased radiation on solar aspects can influence storm slab sensitivity, as well as form melt-freeze crusts on solar aspects while storm slabs remain elsewhere in the terrain. While these processes are common in the spring, they are rare in January in Canada. Storm slabs may also change in sensitivity on certain aspects over time, and so we counted each individual storm slab only on the day it was first submitted. Determining first submission date was difficult at times, as some operations do not submit daily. This was solved through analysis methods, where we based our assessment on the number of operations that submitted a preferential deposition storm slab, rather than the individual number of preferential deposition storm slabs. This way, an aspect-dependent storm slab that was unintentionally counted twice would not influence the results, as the operation which submitted it was already labelled as an operation which sometimes submitted aspect-dependent storms slabs.

5. RESULTS

Within the sample period, 133 different operations submitted at least one storm slab problem. Of those 133 operations, 19.5% submitted at least one preferential deposition storm slab, and 26.3% percent submitted at least one storm slab that included a wind slab (Table 1). This second situation often occurred during storm cycles. Operations that used storm slab for preferential deposition were not confined to one geographic area, and most public bulletin regions contained at least one operation that used the term storm slab for preferential deposition (Figure 3). However, based on the distribution of all operations in Canada, the proportion of operations that used storm slab to represent preferential deposition appears highest on the West Coast and in the Alberta Rockies.

Table 1 – The number of operations that submitted each type of storm slab. Percentages do not total 100%, as they represent a percentage of the 133 operations in each category. Eight operations were listed in both categories.

Operations that submitted…		
	Number	Percent of Total
any storm slab	133	-
a preferential deposition storm slab	26	19.5%
a storm slab that included a wind slab	35	26.3%

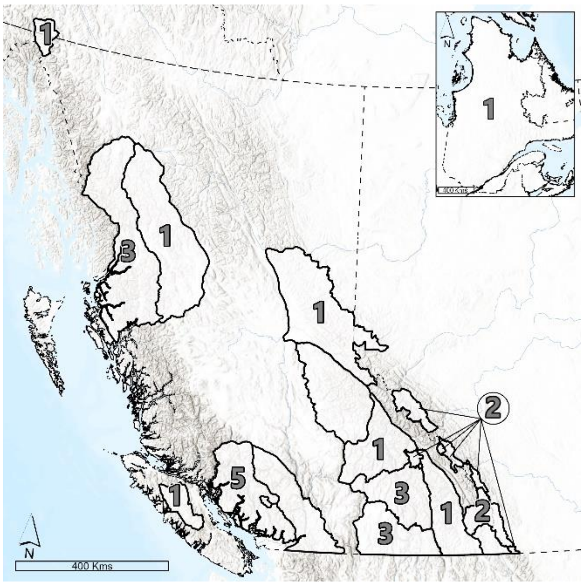

Figure 3 – The number of operations within each public bulletin region (pre-2023) that submitted at least one preferential deposition storm slab problem during the sample period. The circle to the right represents the mountain parks as one unit.

6. DISCUSSION

These results show inconsistency in how the term storm slab was used in the InfoEx during the sample period, and indicate inconsistency in how storm slab problems and wind slab problems are applied in the Canadian avalanche industry. In this study period, one in five operations sometimes used the term storm slab to represent a slab formed through preferential deposition, which is not consistent with the CMAH definitions of wind slab and storm slab. This proportion would likely be higher if the sample period was extended, as it is unlikely that all operations experienced their entire range of possible avalanche conditions in one month. Results of this study demonstrate the complexity of avalanche forecasting, particularly the difficulty in applying a categorical classification to a situation that in reality exists as a continuum.

The root of the semantic discrepancy between storm slab and wind slab may lie with the two different processes by which wind can transport snow. Most would agree that an avalanche problem resulting from redeposition is a wind slab problem. Most would also agree that snow falling straight down results in a storm slab problem. However, problem type becomes less clear when snow falls sideways, as in the case of preferential deposition. Some practitioners may call this a storm slab and some may call it a wind slab. In North America both transport processes are grouped under wind slab by the CMAH (Statham, Haegeli, et al., 2018), while in Europe, preferential deposition is included in the new snow problem (European Avalanche Warning Services, 2023). While both terminology systems have explicit definitions for these avalanche problem types, distinction can be complicated, especially when redeposition and preferential deposition happen simultaneously.

Local weather conditions are one reason some operations could be more likely to call preferential deposition a storm slab problem. The Alberta Rockies and the West Coast are both known for high winds, and these areas had the highest proportion of operations using the term storm slab for preferential deposition. It is possible that due to personal experience and the location in which they were trained, forecasters in windy areas are more likely to describe a slab deposited by relatively less wind a storm slab rather than a wind slab. This could be due to the difference in how soft wind slabs and hard wind slabs behave, and the difference in mitigation strategies applied to each. Another reason could be the desire to use explicit terminology to distinguish between an older now buried wind slab, and a new surface slab associated with an ongoing windy storm. In these cases, applying the term storm slab to a softer or newer wind slab may better support internal operational communication.

Additionally, one in four operations sometimes included a wind slab problem within a storm slab problem. These situations usually occurred during storms, or when uncertainty was high such as in a morning meeting with limited snowpack data. In these cases, avalanche workers were likely using a storm slab problem to identify that it recently snowed, and that they may not know the exact character of the avalanche problem or problems associated with the snowfall. In many cases these storm slab problems also included a dry loose problem or less commonly a wet loose problem. The term storm slab in this case was used similarly to the new snow problem of EAWS which is “related to current or most recent snowfall” (European Avalanche Warning Services, 2023) and so can include all types of dry-snow slab avalanches and dry loose avalanches.

In conversations with many avalanche professionals, we heard a variety of suggestions to improve consistency. Some proposed changes to avalanche problem types, which ranged from creating sub-problems describing each type of wind slab, to reducing the number of avalanche problems by adopting an all-encompassing new snow problem type. Changing the avalanche problem types could necessitate the adoption of two separate lists of avalanche problems, one for professionals, and one for public communication.

Another approach could be to rely increasingly on proposed mitigation strategies when determining problem type, as are listed in the CMAH definitions of each avalanche problem type (Statham, Haegeli, et al., 2018 p. 673-680). The mitigation strategies in the CMAH largely focus on problem identification and avoidance, and could be expanded to include active mitigation. For an operation without a public-facing forecast, creating an avoidance or mitigation strategy is generally the end goal of writing a forecast, and so it makes sense to prioritize this part of the definition for each problem type. While explicit terminology is important, if all workers present agree on the mitigation strategy to be used, then the end goal has been accomplished, even if the terminology debate is ongoing.

The findings of this study must be taken in the context in which they were collected. One month is a relatively short-time period for analysis, and represents a very small sample of total avalanche problems submitted to the InfoEx over the years. The short time period was necessitated by the time-consuming nature of data collection, and different patterns may emerge with a larger dataset. However, this dataset does provide interesting information about the use of the terms storm slab and wind slab in the Canadian avalanche industry, and allows room for further investigation and conversation.

Future studies could include extending the sampling period or applying similar methods to other avalanche problems with overlapping territory, such persistent slab and deep persistent slab. We would also like to expand the wind slab and storm slab terminology study into the United States, although without a widespread professional communication network this would likely be done with public avalanche bulletins. With regards to operations that use storm slab to describe preferential deposition, we have limited information on whether this happens incidentally or is a conscious choice. Further case studies of specific operations could help us better understand this.

7. CONCLUSIONS

Avalanche forecasters and researchers have previously noted inconsistent use of some avalanche problem types both in public and professional communications. This study highlights inconsistencies between storm slab problems and wind slab problems in professional communications. The CMAH specifies that a wind slab problem results from both redeposition and preferential deposition, but during this study period many operations designated preferential deposition as a storm slab problem. Some operations also used the term storm slab to describe a new snow problem which included a wind slab. The inconsistency in differentiating between storm slabs and wind slabs warrants further discussion in the avalanche community to assess if inconsistency poses a problem, and if so, any potential remedies.

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