A DECISION SUPPORT TOOL FOR ASSESSING THE HISTORICAL SIGNIFICANCE OF STORM TOTALS FROM REMOTE AUTOMATED WEATHER STATIONS

Michelle Dalpes[1]*, John Sykes[1], Jason Konigsberg[2], and Spencer Logan[2]

[1] *Chugach National Forest Avalanche Center, AK, USA*

[2] *Colorado Avalanche Information Center, CO, USA*

ABSTRACT: Regional backcountry forecast centers face persistent challenges in understanding the historical significance of ongoing storms. This situational awareness is critical, as forecasters cannot effectively anticipate avalanche conditions during extreme weather events without recognizing when such events are occurring. Historically, there has been no efficient method to rapidly compare multi-day increases in snow water equivalent (SWE) from Natural Resources Conservation Service (NRCS) SNOTEL stations to those observed during past storms. These data are widely used by avalanche forecasters across Alaska and the western United States to monitor storm progression.

Following a historic avalanche cycle in March 2019 in Colorado, forecasters at the Colorado Avalanche Information Center (CAIC) initiated development of a situational awareness tool designed to provide streamlined access to historical SWE data across broad spatial scales and enable comparison with active storm conditions. Forecasters at the Chugach National Forest Avalanche Center (CNFAC) subsequently expanded and automated this tool, transitioning it from a static spreadsheet into a more accessible and dynamic format. This tool is now publicly available for both avalanche professionals and general users via the CNFAC Storm Tracker application.

This paper presents the structure and capabilities of the tool and evaluates its utility through a case study of a high-impact storm event. This case study demonstrates how the tool improves identification of anomalous snowfall patterns, supports real-time decision-making, and provides context for forecasting avalanche conditions during ongoing storms. In addition to operational use, the tool includes a retrospective “look-back” capability, allowing users to compare storms of interest with historical events, enhancing both forecasting practice and post-event analysis.

KEYWORDS: Weather Forecasting and Climate, Avalanche Forecasting, Incidents and Case Studies, Instrumentation and Remote Sensing

1. INTRODUCTION

The concept of comparing current storms to historical events is well established in avalanche forecasting. We developed the Storm Tracker application as an easy-to-use tool to dynamically compare storms. Storm Tracker allows forecasters to place current storms into historical context and support operational avalanche forecasting. Development of Storm Tracker was initially focused on extreme weather events, but its value as a daily tool to put any storm into context to assist in decision making was quickly realized.

For decades, forecasters have recorded weather observations—first by hand and later in digital formats—to identify patterns and place current weather and avalanche conditions within a historical context. Birkeland (2025) recommends maintaining a record of historically significant storms so that current events can be evaluated relative to past storms.

While this concept is widely recognized, efficiently accessing and comparing historical storm data remains challenging. Existing datasets often require manual interpretation or are limited in scope, making it difficult for forecasters to quickly determine how exceptional or average an ongoing storm is.

In Colorado, avalanche consultant, researcher, and engineer Art Mears developed a simple chart that allowed users in the Crested Butte area of Colorado to compare significant storms at the Schofield Pass SNOTEL and evaluate them relative to past events.

* Corresponding author address:
Michelle Dalpes, Chugach National Forest Avalanche Center,
Girdwood, AK 99587;
tel: +1 907-341-9225
email: mik@chugachavalanche.org

Following a historic storm cycle and resulting avalanche cycle in March 2019, the Colorado Avalanche Information Center (CAIC) analyzed data from SNOTEL sites across Colorado. CAIC calculated percentile rankings for increases in snow water equivalent (SWE) over several time intervals at each station and presented these rankings in a table-based format. Recognizing the value of this approach, forecasters from the Chugach National Forest Avalanche Center (CNFAC) collaborated with the CAIC to develop Storm Tracker for the avalanche community.

2. STORM TRACKER DEVELOPMENT

Storm Tracker (https://avystormtracker.com) is a Python-based web application that automates SNOTEL data retrieval, multi-day storm-total calculation, and interactive visualization. It is based on daily SNOTEL records recorded at midnight, which are quality controlled by NRCS, and provide a more consistent dataset for analysis compared to the hourly SNOTEL data which is not quality controlled. One trade-off of using daily data is that the storm tracker lags behind current storm events and is best applied on a daily timescale instead of real time.

Users select any SNOTEL station—or upload a daily snow water equivalent (SWE) time series from another network—and choose a reference date (Figure 1). The application: (1) fetches the station period of record from the NRCS Report Generator (2) Computes positive 1-, 3-, 7-, and 10-day SWE accumulations, treating melt and data gaps conservatively so that the analysis excludes incomplete windows from the storm record, (3) Constructs histograms of historical storm days only (SWE > 0) colored by percentile bands (50th, 75th, 90th, 95th, and 99th) (4) Overlays a bold vertical line for the storm totals on the selected reference date. This design supports both contextualization of ongoing storms and retrospective “look-back” analysis of past precipitation events. Users can download processed time series and histogram figures for forecast discussion, post-event review, or publication (Figure 2).

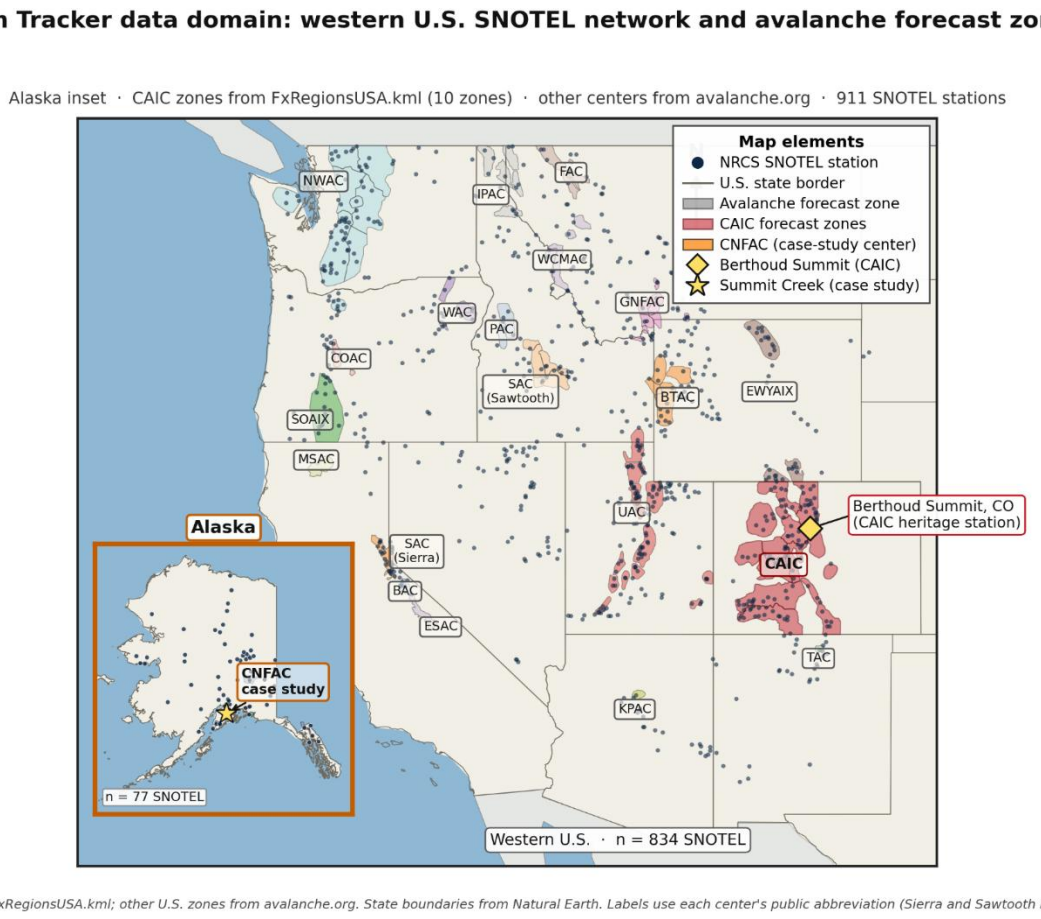

Figure 1: Western U.S. and Alaska SNOTEL stations available in Storm Tracker, with avalanche forecast zones.

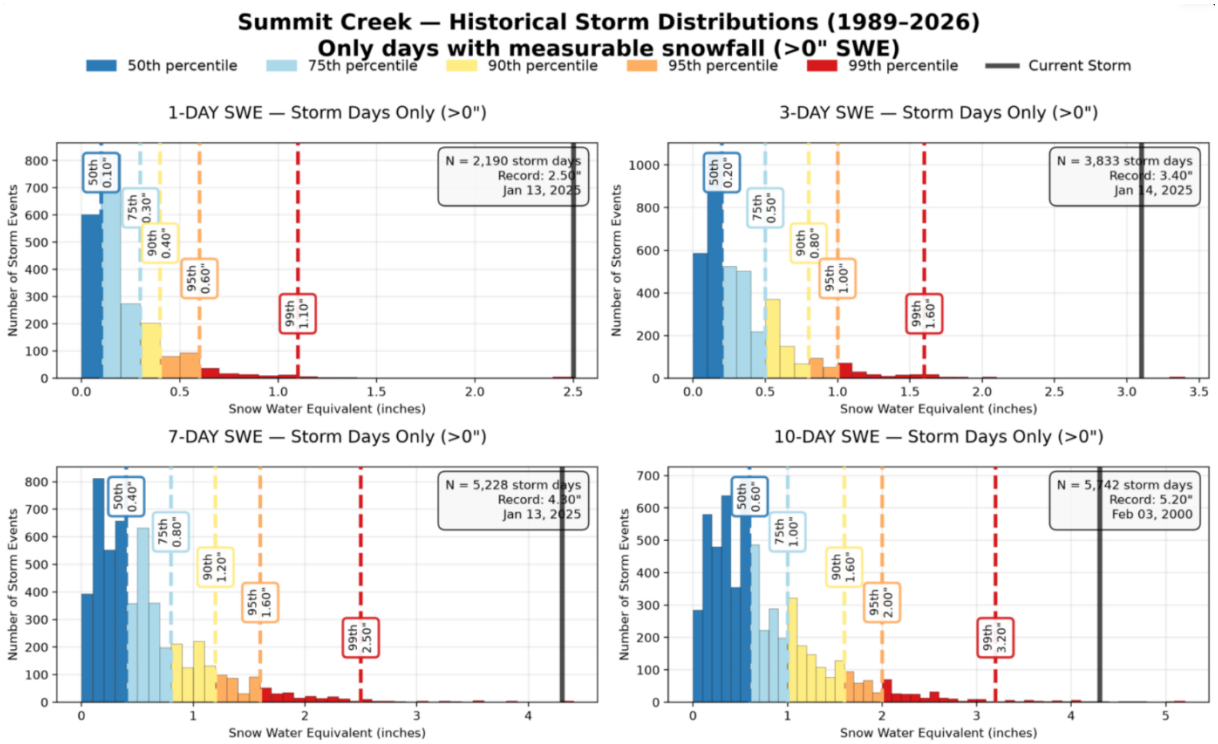

Figure 2: Example from January 13, 2025 of the “Storm Tracker” plots using the Summit Creek SNOTEL in Alaska. The color-coded percentages associated with the 1-, 3-, 7-, and 10-day periods of record are displayed on these histograms with the black bar indicating current SWE. https://avystormtracker.com/

3. CASE STUDY

We examine a case in Alaska where situational awareness of an extraordinary storm could have been improved through use of the Storm Tracker tool. Recognizing that the storm was well outside the historical norm may have supported issuing a higher avalanche danger rating.

3.1 Study Site

Summit Lake is located on the Kenai Peninsula in Southcentral Alaska, USA, between the Turnagain Pass and Seward forecast regions (Figure 3). The Summit Lake area is typically either an Intermountain or Continental snowpack depending on the season (Wagner, 2025). It is 20 miles from the ocean as the crow flies, but the weather and snowpack are very different from its neighboring zones. The 2024–2025 season marked the first year that the CNFAC issued daily avalanche danger ratings for the Summit Lake Zone. Compared with the neighboring Turnagain Pass, Summit Lake receives less recreational use and consequently generates fewer public and forecaster observations. The combination of a continental snowpack and limited observational data presents additional challenges for forecasting in this zone. Due to the relatively sparse data available, the ability to compare current weather with historical data is particularly valuable for assessing avalanche hazard. There are three weather stations that provide relevant weather information for the Summit Lake area. These include the Summit Lake Ridge 1,158m (3,800ft.) and Alaska Railroad Mile 43 1,128m (3,700ft.) for wind and temperature. The Summit Creek SNOTEL 408m (1,340ft.) provides water and SWE information.

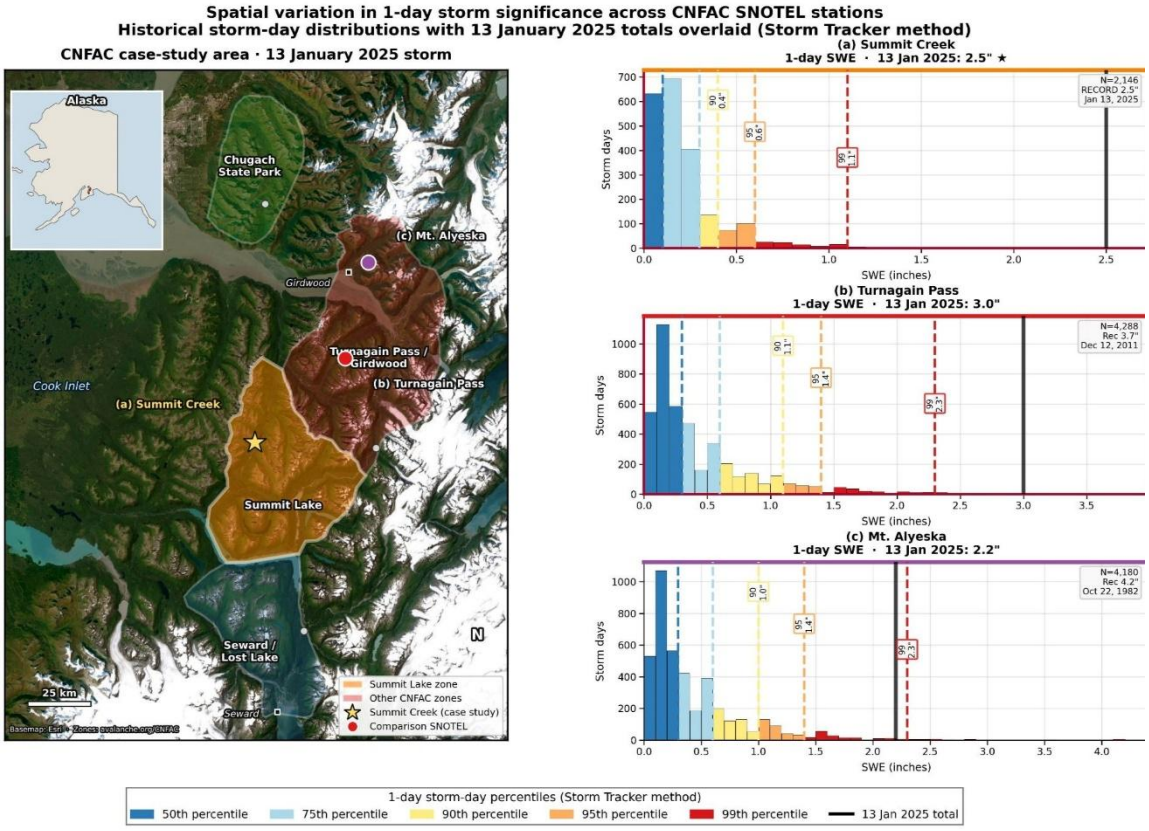

Figure 3: CNFAC case-study map and Storm Tracker 1-day SWE histograms for Summit Creek, Turnagain Pass, and Mt. Alyeska (Girdwood) on January 13, 2025.

3.2 Weather and Snowpack

The 2024-2025 season began warm and wet with a rainline often at 457m (1,500ft.) or above. Periods of storms and clear skies alternated through November, December, and early January. The Summit Lake SNOTEL recorded 26.9cm (10.6 in.) of SWE from October 1, 2024-January 12, 2025. The snowpack consisted of a mix of crusts, facets, and wind slabs in the upper elevations.

Beginning on January 8, 2025 a large storm impacted the area. The Summit Creek SNOTEL recorded the heaviest precipitation on January 13, with 6.35cm (2.5in.) of SWE in a 24 hour period. Winds on January 12th averaged 28 mph out of the east and gusted to 160 mph at the Alaska Railroad Mile 43 station. This new load of SWE was deposited onto a snowpack with poor structure consisting of crusts and facets (Figure 4).

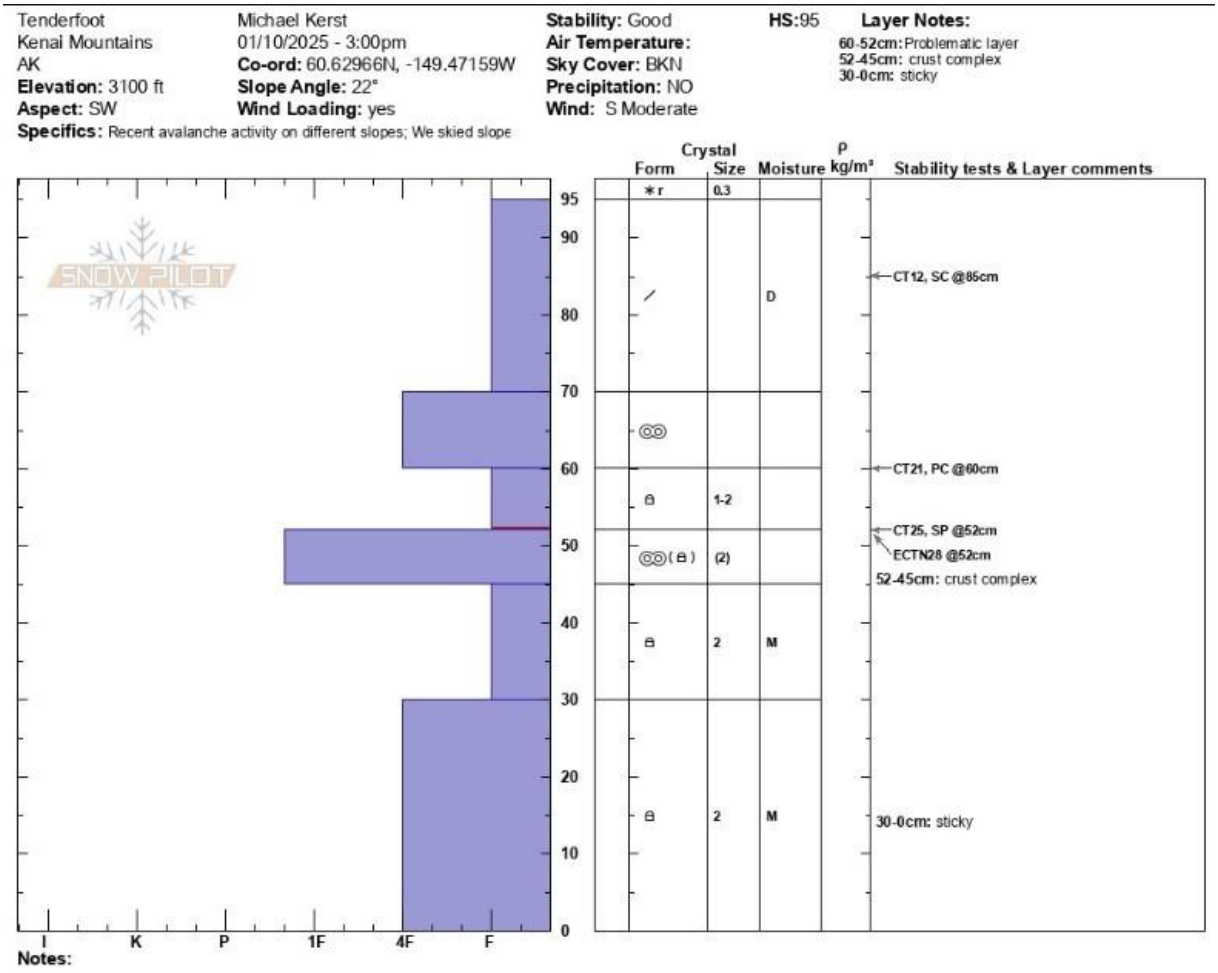

Figure 4: Snow profile on January 10, 2025 at 945m (3,100ft.) on Tenderfoot in Summit Lake, AK

3.3 Avalanches and Danger Rating

During the January 13 storm, a widespread avalanche cycle occurred with many slabs releasing in buried weak layers, four of these at the ground. Observers documented fourteen avalanches ranging from D2 to D3.5, which occurred mostly between 914 and 1,219m (3,000 and 4,000ft.) on all aspects except north. Many avalanches during this cycle went unrecorded and ran to the valley floor (Figure 5).

On January 12th, the CNFAC forecasted High avalanche danger at all elevations and issued an Avalanche Warning through the NWS.

3.4 Hindsight Storm Tracker Data

January 13th (midnight of the 13th) was a 1-day record at the Summit Creek SNOTEL, January 11 to 14th was a 3-day record, and January 6 to 13th was a 7-day record.

Without a storm comparison tool available, forecasters were unaware of the historic SWE accumulations at the Summit Lake SNOTEL site.

After seeing the widespread extent of D2.5 and D3 activity, the forecaster on duty made the hindcast assessment that the danger rating could have been Extreme for that 24-hour period. The CNFAC began development of the “Storm Tracker” tool later in the season and realized that January 13 was a 1- and 7-day SWE record. This information would have helped in the decision-making process to issue an Extreme danger rating rather than High.

During this hindsight analysis, forecasters identified two other storms in January, 2025 that Storm Tracker could have provided valuable historical context. Although they weren’t record breaking, the amount of SWE and resulting avalanche cycles were significant.

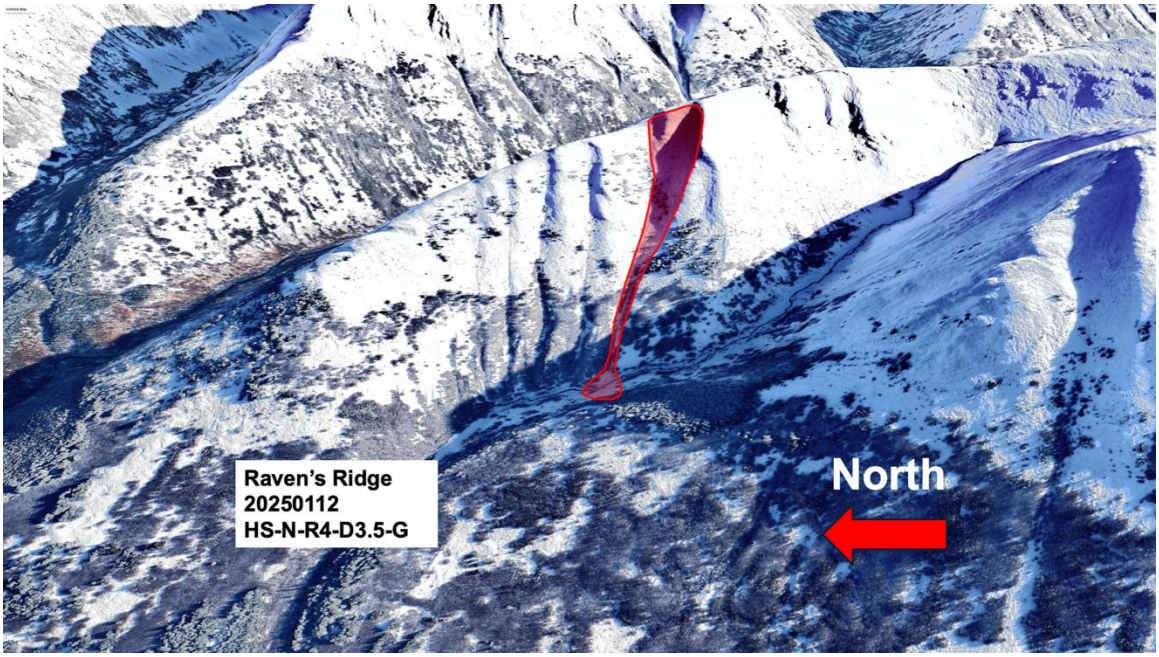

Figure 5: One of the many avalanches that occurred during the storm on January 12, 2025

4. CONCLUSION

As Jim Kennedy, former Snow Safety director at Alyeska for 30 years, used to say, "There are the things we've seen before, and there are things we haven't" (personal communication, December 11, 2011). By providing an accessible way to process and visualize widely available SNOTEL data, Storm Tracker has made the task of comparing current storms to historical events more accessible. It can provide improved situational context about storm systems to help a forecaster make an "on the line" decision when it is difficult to determine which danger rating or determine what operational decision is best for the conditions and the day. While the value of the storm tracker is most obvious during historic events, it can also provide context during more typical conditions to anchor forecasting and operational decisions against objective real world data instead of relying heavily on individual experience. This tool can help users across the industry including ski area personnel, guides, railroad, highway, mining, and other infrastructure forecasters with daily situational awareness and operational decisions.

Future developments of the Storm Tracker could provide map-based visualization of multiple SNOTEL stations to make the tool more useful for regional scale forecasting. There is also potential to expand Storm Tracker to use different input datasets, so it is more accessible in areas that lack SNOTEL records or in different countries with their own weather station networks. The code is open source and contributions and suggestions from professional users are encouraged to help improve the tool and make it more useful for a wide range of avalanche professionals.

SOURCE CODE

Source code for Storm Tracker is available at https://github.com/jmas-seysykes/Storm_Tracker_CNFAC.

REFERENCES

Wagner, W., 2012. Investigating the snow climate of Turnagain Pass, Alaska, https://arc.lib.montana.edu/snow-science/item.php?id=1669.

Birkland, K., 2025. The Starting Zone, At the interface between science and practice, Birkeland Snow and Avalanche Scientific, LLC. https://www.thestartingzonebook.com/.

Peitzsch, E. et al., 2023. Using tree rings to compare Colorado's 2019 avalanche cycle to previous large avalanche cycles, https://arc.lib.montana.edu/snow-science/item.php?id=2936.