SNOWPACK TRACKER: THE DEVELOPMENT AND APPLICATION OF A WEB-BASED VISUALIZATION TOOL FOR AVALANCHE AND WEATHER DATA

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ABSTRACT: New for the 2017-18 season, the Bridger-Teton Avalanche Center (BTAC) website includes tools for interactive display of weather and avalanche data. Developed by Inversion Labs for the BTAC, "Snowpack Tracker" provides a modern graphical display allowing users to interactively switch weather station locations and adjust the displayed time-range from several days to full-season views. These tools fill the need for visualization of data beyond raw weather variables, including derived variables such as snow settlement and multiday cumulative precipitation, and avalanche-specific data including avalanche events and daily hazard rating. The web-based display leverages modern, interactive software tools and can be customized for multiple weather stations and data sources. The Snowpack Tracker display is designed to be an update and enhancement to the commonly used Excel sheet originally developed by Ian McCammon and others. This tool has provided forecasters, educators and the public with rapid access to both recent and historic data, with potential for further application in additional regions over coming seasons.

KEYWORDS: avalanche forecasting, software, data visualization

1. INTRODUCTION

Initially developed for the BTAC in northwest Wyoming (USA), "Snowpack Tracker" is a modern web-based visualization tool for snow and avalanche data.

Development of this tool was motivated by the need to quickly access and visualize current data from multiple weather stations at Jackson Hole Mountain Resort (JHMR). In addition, the BTAC needed a tool to access and graph data from a unique database with 44 seasons of historical records.

With full-time operational use during the 2017-18 season, Snowpack Tracker gained popularity with forecasters, guides, educators and the public, averaging 40-50 site visits per day. The current website (www.snowpacktracker.com/btac) includes two display styles, with the ability to add custom pages for additional avalanche centers in the future.

2. FEATURES AND USER INTERFACE

The standard display for Snowpack Tracker defaults to graphs of 24-hour data for the previous 30 days, sourcing data from five weather stations at JHMR (Figures 1 and 2). Display panels include snow study plot observations (new snow, snow water equivalent, total snow depth, and settlement) wind speed and direction (average and gust), minimum and maximum air temperature, avalanche events colored by crown depth, and avalanche hazard rating for three elevation zones.

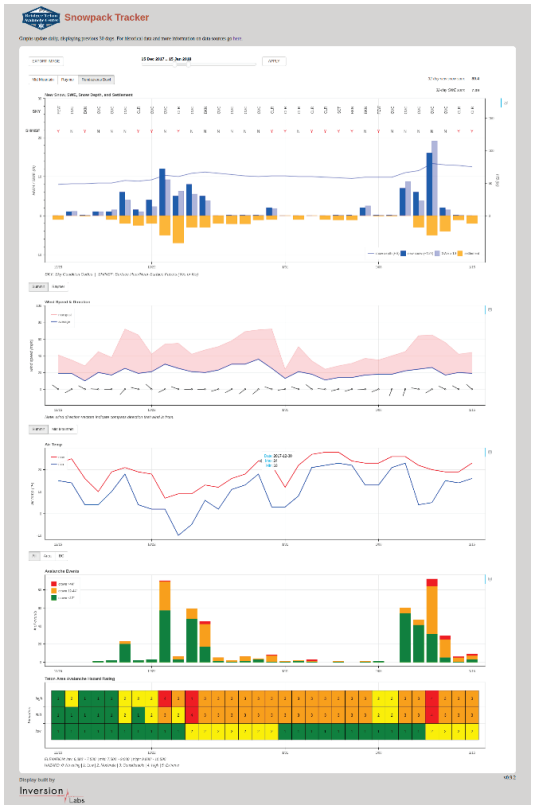

Figure 1. Screenshot of the default display for Snowpack Tracker, showing 24-hr data for the previous 30 days.

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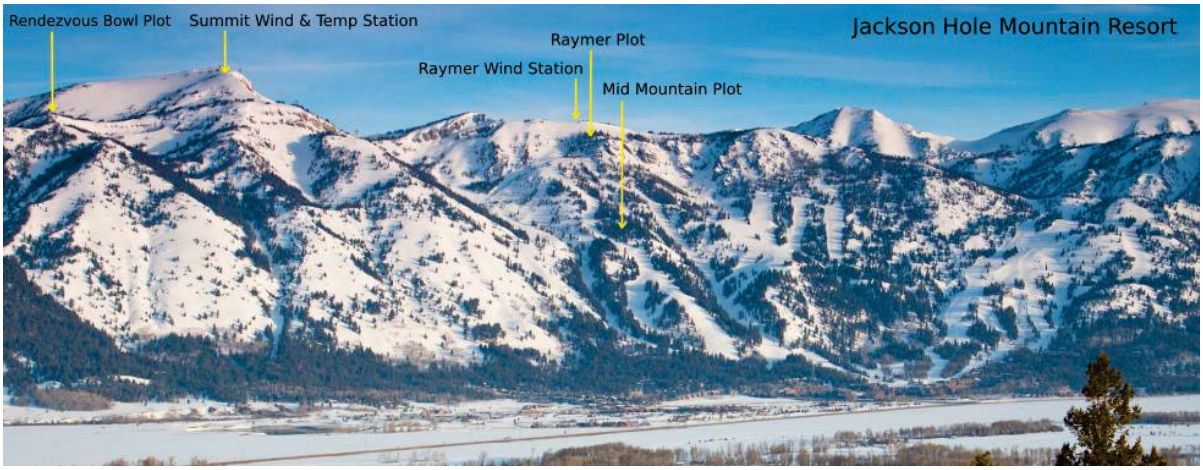

Figure 2. Locations of weather stations and snow study plots at Jackson Hole Mountain Resort (Wyoming, USA).

For the research-oriented user, an additional display ("Historical Avalanche and Weather Data") leverages BTAC's historical database providing graphs of daily data for any season back to 1974 and providing panels for additional derived weather variables (Figure 4).

Features of Snowpack Tracker include:

- Display of current data with a database connection for automatic hourly updates
- Buttons to switch data sources between multiple weather stations and snow study plot locations, and to toggle avalanche events between in-bounds hazard reduction events ("Area"), backcountry events ("BC"), or all events ("All")
- Date-range slider tool to set user-defined start and end dates, and a drop-down menu to switch to previous seasons
- Interactive tools including pan, zoom, and a hover tool to display data values
- Image export button to download high-resolution images for use in print or presentations
- Graphs of derived weather variables, including snow settlement, new snow density, cumulative multi-day precipitation totals, and 24-hr wind totals
- Responsive design for desktop and mobile displays

The Snowpack Tracker display is inspired by and intended to be an update to the commonly used spreadsheet layout originally developed by Ian McCammon and others (Figure 3). The widespread adoption of the spreadsheet in the U.S. indicates that the variables chosen and general display format is relevant and useful for avalanche forecasting. Snowpack Tracker builds on the McCammon et al. layout by adding key features such as custom time ranges, flexibility for plotting additional variables, interactive switching between station locations, and automated hourly updates.

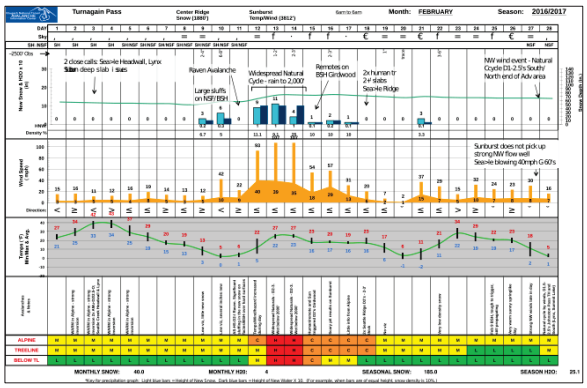

Figure 3. Example of the McCammon et al. Excel spreadsheet, published by the Chugach National Forest Avalanche Information Center as part of their seasonal summaries.

3. TECHNICAL APPROACH

Snowpack Tracker can ingest data from a variety of sources. "In-house" data sources can include snow study plot observations, avalanche event data, and daily avalanche hazard ratings. In addition, automated weather station data can be read from an API service such as the Mesonet API from MesoWest/SynopticLabs which currently includes data from nearly 70,000 weather stations in North America.

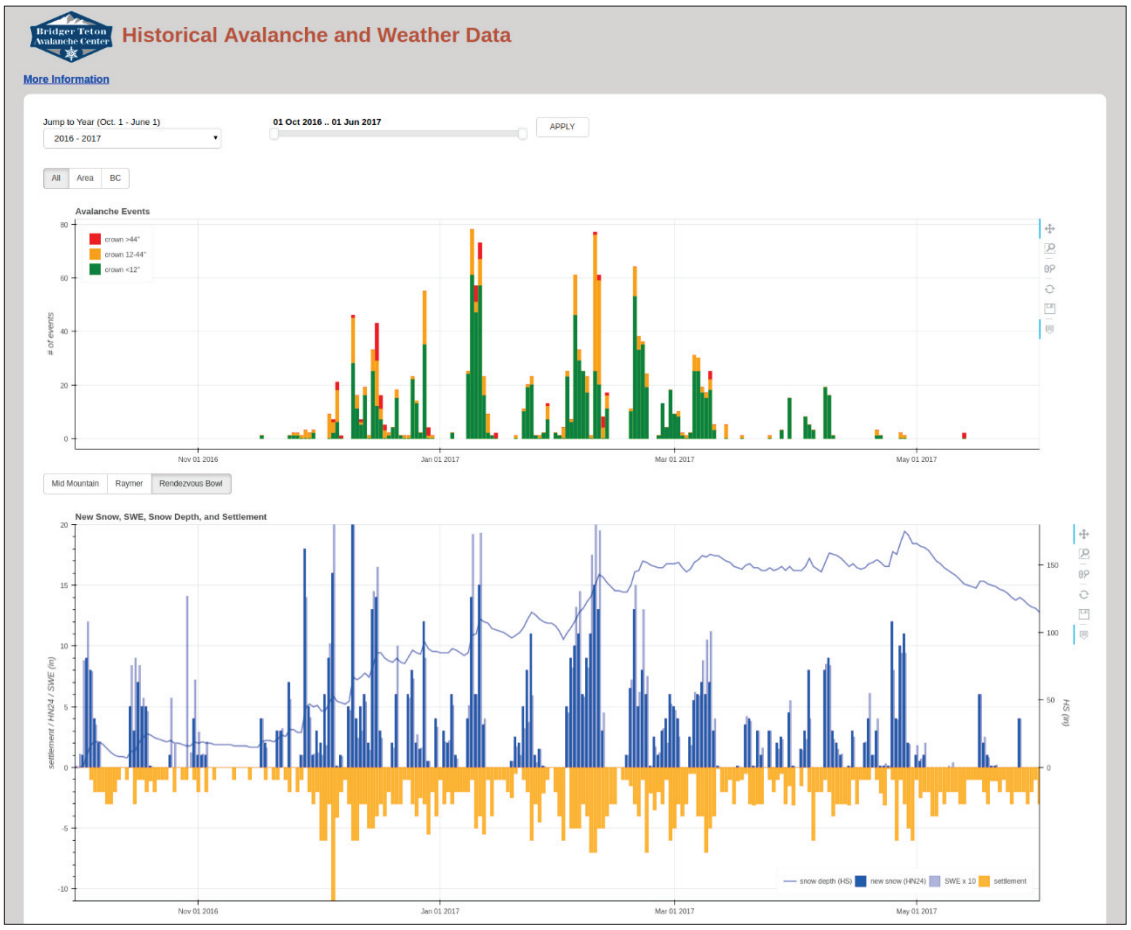

Figure 4. Screenshot of the first two panels from the “Historical Avalanche and Weather Data” page, displaying data for a full season (Oct. 1 2016 – June 1 2017). Five additional display panels are not shown.

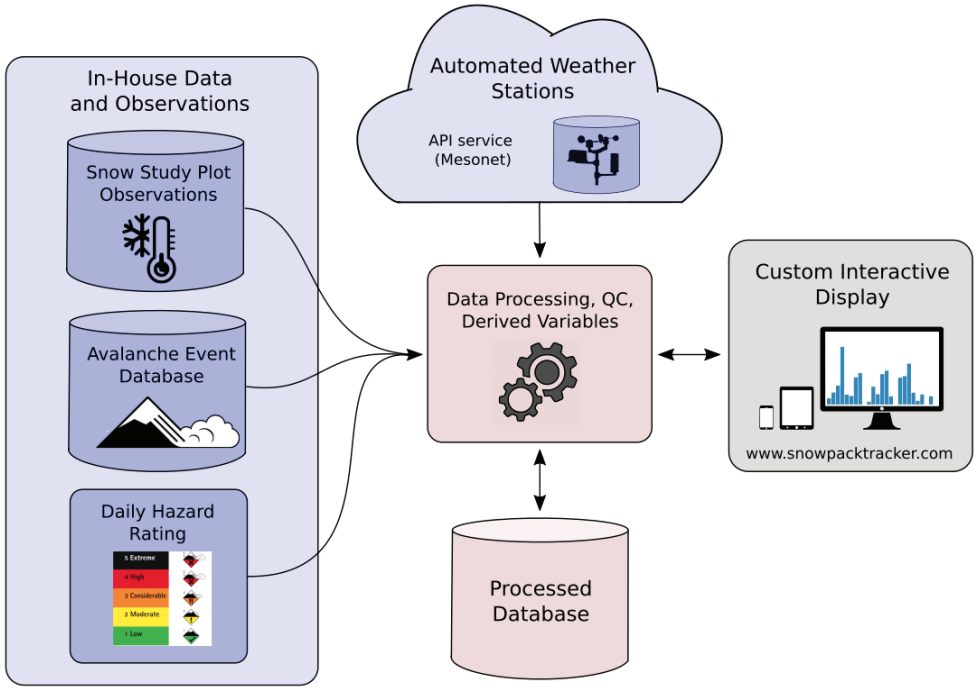

Figure 5. Schematic showing the general flow of data ingest, data processing, and rendering of the web display.

The general architecture for the Snowpack Tracker application is shown in Figure 5, and includes:

- Data ingest from “In-house” data sources and automated weather stations.
- Data processing, quality control, and calculation of derived variables on cloud servers.
- Creation of a standardized database for processed data that backs the web display.
- Rendering of the data in a custom web display, where user interactions access data from the underlying processed database.

Snowpack Tracker uses the Bokeh visualization library (https://bokeh.pydata.org/en/latest/), which offers high quality interactive plotting in the style of D3.js. Bokeh allows developers to write custom plotting code in Python which is then rendered in a browser via BokehJS, Bokeh’s javascript client library. We use the Bokeh server to enable user interactions with widgets such as buttons, drop-down menus, and date-range sliders.

The web application is built using Flask and deployed and hosted on Heroku, using an Amazon S3 bucket as the persistence layer containing the underlying processed database. Fast load speeds and widget interaction response times are achieved by rendering discrete slices of data from the full database. When a user requests a new time range or a new location via widget interactions, the Bokeh server is called to build new data sources for each panel from the underlying processed database and render the data in the browser.

4. FUTURE DEVELOPMENT

For the 2018-19 season, Inversion Labs will be developing an additional page for the BTAC displaying hourly data from automatic weather stations for the previous 7 days, intended to show storm cycles at higher temporal resolution. Although the original application was aimed at tracking seasonal changes in the snowpack through time using 24-hr data, the new hourly display will use the MesoWest/SynopticLabs API and will allow users to monitor conditions in real-time. This tool will likely be expanded to display data from all of the 18 stations in the BTAC network (spanning three forecast areas).

Snowpack Tracker can be applied to a variety of data sources and has potential for use by additional avalanche centers or highway avalanche control programs. Inversion Labs is also working on building capability for the Snowpack Tracker display to be populated from bulk upload of the McCammon et al. Excel spreadsheets. This will make it possible to visually browse historic datasets for any avalanche center that has been tracking weather and avalanche conditions using the Excel sheet.

ACKNOWLEDGEMENT

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We also acknowledge and support the work of open-source software developers providing tools that are used throughout this application: Flask, Bokeh, Python, and Pandas.

The Snowpack Tracker display incorporates layout elements from an Excel sheet originally developed by Ian McCammon, Bill Nalli, and Craig Patterson.