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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Enhancing the operational value of snowpack models with visualization design principles" *by* Simon Horton et al.

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—SUMMARY—

The manuscript applies the visualization design framework proposed by Munzner (2009) to an established workflow for avalanche hazard assessment (CMAH). The goal is to enhance the interpretability and increase the relevance of numerical snowpack models for the avalanche forecaster. Snowpack models in avalanche forecasting are the equivalent to numerical weather prediction models (NWP) in weather forecasting. While weather forecasting nowadays heavily relies on NWPs, snowpack models are only sparsely used in operational avalanche forecasting. Accessibility, interpretability,

relevance and integrity of snowpack models are not yet good enough for operational purposes a recent study by Morin et al claims. While issues of accessibility and integrity are not addressed in this manuscript, the main reason for poor interpretability is accorded to poor visualization of snowpack model output, which also reduces their relevance to the avalanche forecaster. Existing visualization tools are designed by the model developers with evaluation of model performance in mind, but not the operational forecaster (end-user). This manuscript presents a top-down approach for visualizing snowpack models with the forecaster/user in mind. The authors suggest that the visualization of snowpack model output should help the forecaster to answer the key questions from the conceptual model of avalanche hazard (CMAH). They demonstrate their design by applying it to a regional avalanche forecasting scenario. The study concludes that the presented top-down design approach is superior in an operational setting based on a small user survey.

—GENERAL COMMENTS—

This work is a relevant technical contribution. It describes a thorough process on how to improve snowpack visualization in operational avalanche forecasting. The avalanche community in North America, but also internationally, will benefit from these results. I found it well written and structured. Figures are of high quality. I recommend to publish the manuscript. I only have minor suggestions on how to improve the paper.

It seems like the target audience for the suggested visualizations are regional avalanche forecasters that operate with forecasting areas of several hundreds to thousands sq.km. The language used and the given example address this audience. I miss a discussion on other operational settings and more extreme cases, i.e. very large forecasting areas and high resolution model (large amount of data) and small forecasting regions and poor model resolution (too little data). Could you discuss what needs to be done to transfer the presented plots to a smaller scale? Can these visualizations be beneficial for managing avalanche safety in a ski resort? Is there a minimum number of simulated snow profiles to apply your designs? On the other hand, an avalanche

forecaster can normally not wait for several minutes for a plot to be displayed. Could you discuss performance on a standard workstation/PC? How long does it take to load and update the dashboard in your example on common hardware?

In my opinion an important part of showing model output is to provide a measure/display of uncertainty or an indication of when the model is off. In my experience, forecasters rejected model output because it is often hard and time consuming to evaluate if the model is providing reasonable results. Thus, be able to plot model output against field data or other sources will help to improve integrity. You mention this at the end of your conclusion. Could you, in addition, discuss briefly why this is not part of your study? I suggest to add a short section that summarizes the main issues with assimilating snowpack observations in snowpack models.

A drawback of this study is the small and rather arbitrary user survey on the effectiveness of the proposed visualization design.

—TECHNICAL COMMENTS—

p2 l8: should be "Morin et al. (in press)" as in prev sentence

p2 l10: What is meant by "workstations"? To me this is hardware - a PC! They are normally not specifically designed for showing field data. I assume you address the lack of proper software that can make model output accessible to the forecasters. A hardware issue might be lack of CPU/GPU power to effectively handle large amounts of data/images.

p2 l13: Snowpack models "relevance" comes from their ability to produce information over a large spatial scale, something field observations can not. So I think their relevance is less of a problem than their integrity, i.e. difficult to compare to field observations due to scale issues in the forecing data.

p2 l17: Could you provide an example of a "conventional method" - individual snow profiles?

p3 l19: You could provide "assess the spatial distribution of weak layers" as an example for "major needs".

Figure 1: The figure caption could be more detailed and explain the main features and abbreviations of the shown chart. This would ease the understanding for readers outside the avalanche community.

p7 l18-19: The given example is typical for a regional avalanche forecast and the presented visualizations work well in this given case. Could you discuss (later in the text) the extremes, very large forecasting areas and high resolution model (large amount of data) and small forecasting regions and poor model resolution (too little data).

Table 2: Layers of large facets can be an avalanche problem, too. However, facets (FC) are treated as bulk layers here. What is the criteria (in SNOWPACK) that separates DH from FC - size only - if yes, what is the threshold?

p9 l5: remove "and"

p9 l11: "...each day OF the season."

Figure 4: Can you explain why the percentage exceeds 100% on some days? E.g. Oct 21 or Noc 22 and 25. Does the plot only evaluate if a layer is present (boolean - regardless of layer thickness) in a simulated profile or is the percentage each layer takes up of the total snow depth within each simulation regarded and used as a form of weight?

Figure 5: Have you considered a "polar/radar plot" for each elevation band? I can imagine that it will show the presence of layers with regard to aspect more clearly. However, the information on snow depth will be difficult to integrate.

p16 l 2: "...the principles outlineD in..."

p16 l 16: Could you provide examples for "other operational tasks"? And discuss briefly benefits and challenges (see General Comments).

p16 l26-27: What do you mean by "...prototypes were accessed externally from existing workstation..."? Were the plots provided by a server? Why is it critical to integrate visualizations into forecasting workstations? Do you mean integrate into software used by the forecasters?

p17 l3: Consider to add "...two of the four major percieved issues (BESIDES ACCESSIBILITY AND INTEGRITY) with ..."

p17 l11-12: The sentence "As highlighted by..." should be removed or rephrased since it is not clear how it fits into your conclusions. Please be more specific on your findings.

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