NHESS-2019-379 - Referee Comment

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Referee: Bret Shandro

General Comments

The scientific significance of this manuscript is good. The manuscript presents a risk management method for monitoring snow avalanches for a Himalayan highway and outlines a novel approach intended to streamline the avalanche hazard forecasting process. The methodology and conclusions make a convincing argument for potentially improving the data management process for avalanche forecasters. Specifically, for the efficient filtering of data for the avalanche forecasting process. Additionally, I agree with the authors that the false alarm rates can indicate avalanche hazard even without observed avalanches (Haegeli et al., 2010).

However, the scientific quality of this manuscript is fair because of the limited description of the weather inputs avalanche observation dataset used for training the random forest model. The manuscript communicates the study content, however, the paper may benefit from increased engagement after a thorough English language and grammatical review. Additionally, the presentation quality of the manuscript is poor.

While the technical and English language revisions required are relatively minor, the manuscript requires additional editing before publication. Figure numbers appear to be incorrect (figure 4, line 296, 323, 400, 413), figures are not labelled or explained, additional space on line 251, 267.

Specific Comments

The methodology could be more relevant to avalanche processes if the methodology used internationally accepted parameters for weather and snow observations (CAA, 2016).

The manuscript provides a methodology that aligns with practitioner experience for certain avalanche problems (Haegeli, Atkins, and Klassen 2010).

Line 31: Avalanche forecasting aims to identify the location of snowpack weakness and its triggering risk specific avalanche problems, their spatial distribution and sensitivity to triggering (Statham et al 2018).

Line 35: Citation required for the snowpack spatial variability, suggest Gaume et al (2014):

In numerous lines, the manuscript uses the terms 'threat', 'hazard', and 'risk' interchangeably. Avalanche hazard is a source of potential harm or loss. The potential for an avalanche(s) to cause damage to something of value. It is a function of the likelihood of triggering or frequency, and the avalanche size or magnitude. Avalanche risk is the probability of harm or cost resulting from the interaction between avalanche hazard and a specific element(s) at risk (CAA 2015, CSA 2015, Statham, 2008).

Line 80: (Pozdnoukhov et al., 2008) Pozdnoukhov et al. (2008) use support vector machines (SVM) on high dimensional feature vectors…

Section 3, the description of the study location includes the BG road axis. I believe BG road alignment would be more descriptive.

Since the model's ability is limited by the input parameters, could the input parameters derived from observed parameters be formatted like the observations gathered by avalanche practitioners? If the derived input parameters more closely match the actual forecasting process, the random forest rules may result in more insightful forecasting thresholds. For example, instead of inputting the snowfall amount in the past 2,4, and 10 days, CAA (2016) snow observations include, 12-hour and 24-hour snowfall and precipitation amounts. Another important forecasting input is the Height of Storm (HST) amount.

The authors have extensive references for relevant random forest studies. However, the manuscript does not include any references for studying avalanche observations. Weighting the avalanche days based on the number of observations or avalanche size may improve the dataset filtering and model output (Thumlert et al 2014, Laternser & Schneebeli 2003, Hägeli & McClung 2003).

Line 232: …sufficient standing snow Height of Snow (HS; CAA, 2016).

Line 231, Table 4: To address sampling bias due to a portion of the dataset having no avalanche hazard, the manuscript filters for observations with a SNOW-DEPTH > 50cm. To evaluate the validity of this assumption the reader requires the elevation of the SNOW-DEPTH parameter.

Figure 5-6 and Table 5 appear to present the same information, either the figures or the table could be removed.

The impact of the example tree diagrams could be improved by explicitly describing the colour scheme. I find it difficult to understand the reason for colour changes in the parent/child nodes. While I assume the leaf node colour scheme is green/yellow/red for low/medium/high outputs, an explicit explanation would be beneficial.

Line 425: The suggested rule only makes sense if the temperature trend is warming, however, if the trend is cooling and satisfying the rule the snowpack would likely be stabilizing. A parameter indicating temperature trend would likely assist the model with identifying useful forecasting rules.

Line 441, Table 8: The sample size should be included.

On line 466, I assume that the manuscript is describing a persistent slab avalanche problem (Heageli et al 2010) or old snow problem (Harveyet al 2009).

Table 3: The formulas presented for the confusion matrix and performance measures appear to be applied correctly. However, there is inconsistent use of a and y for different performance measures.

Figure numbers appear to be incorrect (figure 4, line 296, 323, 400, 413)

Additional space on line 251, 267.

Technical Corrections

Line 120-125: The reader would benefit from an explicit explanation of the random forest terms non-leaf node, leaf node, and child node.

Line 176: The ~~formation~~ start zone elevation ~~altitude~~ of avalanche sites in the area ranges…

Line 179: Is this sentence describing the snow climate or the meteorological climate? If it is meant to describe the snow climate, please review Haegeli and McClung (2007) and Sharma & Ganju (2000) for snow climate classifications. The continental snow climate exhibits colder temperatures, more frequent periods of clear skies and less snowfall, which produces a thinner snowpack that is conducive to the formation of depth hoar and persistent weak layers (McClung and Schaerer, 2006).

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