TOWARDS A FULLY MODEL-BASED AVALANCHE HAZARD ASSESSMENT: INVESTIGATING THE IMPACT OF INPUT DATA ON MACHINE LEARNING PREDICTIONS.

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ABSTRACT: Operational avalanche forecasting mostly relies on manual snow profiles, snow instability observations, and weather data to assess the avalanche danger. Novel machine learning tools were developed to support the Swiss avalanche warning and showed promising results when forced with measured weather data from automatic weather stations (AWS). While the danger level is published at a regional scale, decision-makers and practitioners gather information at a much smaller spatial scale. Striving towards a higher spatial resolution, we investigated the predictive power of machine learning algorithms using weather forecast data (COSMO1A). To model snow stratigraphy at around 140 automatic weather stations (AWS) across Switzerland during the winter season of 2021-2022, we utilized downscaled COSMO reanalysis data and the downscaling and data assimilation techniques of the OSHD model framework to force the snow cover model SNOWPACK. We then applied three random forest (RF) models to predict the avalanche danger level, dry snow instability, and wet snow avalanche activity. We compared these predictions, based on downscaled reanalysis and OSHD precipitation data, to model predictions using measured meteorological data from AWS. First results showed that although more persistent layers were simulated with data from weather forecast models, the predicted danger level agreed well with predictions from AWS data (correlation coefficient 0.91). On the other hand, dry snow instability was largely affected by differences in modeled snow stratigraphy, resulting in much higher predicted dry snow instability when forced with data from weather forecast models. With higher danger levels estimated by the Swiss avalanche warning, predicted dry snow instability increased, suggesting that new optimal thresholds of the RF classifiers can be derived. While predicted wet snow activity was less affected by modeled snow stratigraphy, some shifts in timing of predicted wet-snow avalanches were observed. Our results show that RF models based on weather and snow stratigraphy data are less sensitive to input data than RF models relying solely on snow stratigraphy. Yet, by adapting threshold values, these RF models could be forced with spatially interpolated data for automated avalanche forecasting at high spatial resolution.

KEYWORDS: Numerical avalanche forecasting, snow cover modeling, random forest models, weather prediction models.

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