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Sensitivity Analysis of a Spatio-Temporal Avalanche Forecasting Model Based on Support Vector Machines

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The recent progress in environmental monitoring technologies allows capturing extensive amount of data that can be used to assist in avalanche forecasting. While it is not straightforward to directly obtain the stability factors with the available technologies, the snow-pack profiles and especially meteorological parameters are becoming more and more available at finer spatial and temporal scales. Being very useful for improving physical modelling, these data are also of particular interest regarding their use involving the contemporary data-driven techniques of machine learning.

Such, the use of support vector machine classifier opens ways to discriminate the “safe´´ and “dangerous´´ conditions in the feature space of factors related to avalanche activity based on historical observations. The input space of factors is constructed from the number of direct and indirect snowpack and weather observations pre-processed with heuristic and physical models into a high-dimensional spatially varying vector of input parameters. The particular system presented in this work is implemented for the avalanche-prone site of Ben Nevis, Lochaber region in Scotland. A data-driven model for spatio-temporal avalanche danger forecasting provides an avalanche danger map for this local (5x5 km) region at the resolution of 10m based on weather and avalanche observations made by forecasters on a daily basis at the site.

We present the further work aimed at overcoming the “black-box´´ type modelling, a disadvantage the machine learning methods are often criticized for. It explores what the data-driven method of support vector machine has to offer to improve the interpretability of the forecast, uncovers the properties of the developed system with respect to highlighting which are the important features that led to the particular prediction (both in time and space), and presents the analysis of sensitivity of the prediction with respect to the varying input parameters. The purpose of the sensitivity analysis is to shed light on the particular abilities of the model in assessing the likelihood of avalanche releases under evolving meteorological/snowpack conditions. Both spatial resolution (the abilities to produce reliable forecasts for individual avalanche paths) and temporal behaviour of the model are explored in details. Based on the sensitivity analysis, the uncertainty estimation for the provided forecasts is discussed. Particularly, the ensembles of prediction models are run and analysed in order to estimate the variability of the provided forecast and assess the uncertainty coming from the variety of sources: imprecise input data, uncertainty in weather forecast, sub-optimal parameters of the prediction model and variability in the choice of the training dataset.