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Prediction of the regional catchment susceptibility for debris flows using multiple hydro-meteorological variables

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Debris flows represent a threat for societies in alpine regions and are typically triggered by excessive water input from long lasting rainfall (LLR), short duration storms (SDS) or intense snow melt (SM) into torrential watersheds. The prediction of debris flow events mostly relies on rainfall intensity and duration (I-D) alone, which is often less reliable for practical applications because of the high spatial variability of precipitation. To overcome this limitation, we utilize multiple hydro-meteorological variables like snow melt, evapotranspiration, soil moisture from a hydrological simulation besides station data of precipitation and temperature to predict the temporal susceptibility of the Montafon watershed to debris flows between 1953 and 2013. Therefore, we setup four Naive Bayes Classifier models of different complexity, ranging from simple rainfall only to multi-variable, multi-trigger type as well as a classical I-D curve and evaluate the performance using Receiver Operating Statistics. Results show that the watershed is in very different states in dependence of the trigger of either LLR, SDS or SM on the 38 documented debris flow event days in the region. The multi trigger-type models outperform the simpler models as well as I-D curve by showing both, higher true positive rates and lower false alarm rates. We conclude that, the consideration of hydro-meteorological variables can help to improve debris flow prediction in future.