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Nowcasing Foehn using the Adaboost machine learning algorithm

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The south foehn is a characteristic downslope wind storm in the valleys of the northern Alps in Europe that demands reliable forecasts due to its substantial economic and societal impact. Traditionally, foehn is predicted based on pressure differences and tendencies across the Alpine ridge. Here we propose a new objective method for foehn prediction based on a machine learning algorithm (AdaBoost). Three years (2000-2002) of hourly simulations of the Consortium for Small-Scale Modelling (COSMO) numerical weather prediction (NWP) model and corresponding foehn wind observations are used to train the algorithm to distinguish between foehn and non-foehn events. The predictors (133 in total) are subjectively extracted from the 7-km COSMO reanalysis dataset based on the main characteristics of foehn flows. The performance of the algorithm is then assessed with a validation dataset based on a contingency table which concisely summarizes co-occurrence of observed and predicted (non-)foehn events. The main performance measures are: probability of detection (88.2%), probability of false detection (2.9%), missing rate (11.8%), correct-alarm ratio (66.2%), false-alarm ratio (33.8%) and missed alarm ratio (0.8%). To gain insight into the prediction model, the relevance of the single predictors is determined, resulting in a predominance of pressure differences across the Alpine ridge, i.e. similar to the traditional methods, and wind speeds at the foehn stations. The predominance of pressure-related predictors is further established in a sensitivity experiment where $\sim$2500 predictors are objectively incorporated into the prediction model using the AdaBoost algorithm. The performance is very similar to the run with the subjectively determined predictors. Finally, some practical aspects of the new foehn index are discussed, e.g., the predictability of foehn during the four seasons. The correct-alarm rate is highest in winter (86.5%), followed by spring (79.6%) and autumn (69.2%). The lowest rates are found in summer (51.2%).