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Spatial prediction of temperature inversion using machine learning methods and GIS

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Improving spatial prediction of climatic variables (temperature, precipitation, wind) that strongly depends on topographical characteristics is still an essential study both for meteorological research and natural hazards assessment. The specific topic of this study was to employ machine learning algorithms (multi layer perceptron and support vector machines) for mapping of temperature inversion in mountainous regions. Temperature inversion occurs in the mornings of winter months under stable atmospheric conditions. Physical models meet significant difficulties in modelling this non-linear phenomenon which depends strongly on topography. At the same time, the usual spatial prediction methods concerned with geostatistics rely on the modelling of variograms which is non evident for this phenomenon at the spatial scale of observations.

The general idea of this study was to extract these non-linear relations from empirical data (observations from the network of automatic meteorological stations) with the help of machine learning methods. GIS were employed to calculate several topographical characteristics like slope, curvature and differences of smoothed relief at diverse scales from a high-resolution DEM. A classification task was first formulated in the feature space of the topographical features to discriminate meteorological stations below the inversion layer and the ones above it. Feature selection method was applied to select the relevant features for the latter task. Support vector machines classifiers were used providing the probabilistic interpretation. The resulting temperature inversion indicator gives information about the probability of cold air layer formation on flat surfaces in the bottom of the valleys at given conditions. The main goal of this methodology was to reduce dimensionality of data and produce robust predictors. The final step was to use machine learning methods (neural networks and support vector machines) to predict air temperature. For the visual analysis which simplifies the validation of the prediction mapping, GIS tools and web-based technologies were used.

The particular case study selected to present the methods concerns the prediction of the air temperature between 6 and 7 o'clock of the 5^{th} February 2007 in Switzerland, when a strong inversion was observed. The whole study was carried out in a pure data-driven way and the results are quite promising. As a conclusion, we discuss the use of data-driven machine learning models for the spatial mapping of climatic variables in a fully automatic mode.