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Neural networks and geostatistics for mapping of climatic data in mountainous regions

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Efficient an accurate spatial prediction (mapping) of meteorological information over regions characterized by a complex topography is an important task both from fundamental research and applied (natural hazard assessment, decision making) points of view. The principal topic of this paper deals with the comparison of different advanced prediction models applied for modelling the spatial distributions of temperature and precipitation in Switzerland having complex topography.

The main methods applied are based on geostatistics (family of kriging models) and on application of artificial neural networks (multilayer perceptron). Special attention was paid to the contribution of altitude to mapping results. In the latter case digital elevation model was used at the stage of model development and mapping.

Geostatistical models are model-dependent linear models assuming some hypotheses of spatial stationarity. They rely on experimental analysis and modelling of spatial correlation functions - variograms. Artificial neural networks (ANN) are data-driven nonlinear models. In order to carry out comparison between models raw data were split into training and validation data subsets. The comparison of these methods is mainly done in terms of validation RMSE (Root-mean-square-errors) and reproduction of global statistics, like correlations and variograms. It is well known that some climatic data, e.g. temperature, are highly linearly correlated with altitude. Therefore for linear geostatistical models such situation is close to ideal. Application of ANN is this case can help to understand black box modelling and to compare the results with geostatistical “benchmark” studies. The robustness of both approaches in relation to the quality of the input information is studied as well by shuffling altitude.

In order to analyze the behaviour of the models some particular meteorological situations were considered. For example, the relationship between temperature is linear in

summer months and non linear in winter ones (presence of temperature inversions). On the other hand, the spatial patterns of precipitations differ from situation to situation and the variability could be locally correlated with topography.

The best results were obtained with kriging with external drift model and with artificial neural networks using ANNEX-type of model - artificial neural network with external drift. Stability, nonlinearity and robustness of ANN demonstrated in all considered cases provide a basis for wide recommendation of ANNEX models for climatic and meteorological data analyses and mapping.