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Spatial analysis of precipitation in a high-mountain region: Exploring methods with multi-scale topographic predictors and circulation types

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Statistical models of the relationship between precipitation and topography are key elements for the spatial interpolation of rain-gauge measurements in high-mountain regions. This study investigates several extensions of the classical precipitation-height model in a direct comparison and within two popular interpolation frameworks, namely linear regression and kriging with external drift. The models studied include predictors of topographic height and slope, eventually at several spatial scales, a stratification by types of a circulation classification, and a predictor for wind-aligned topographic gradients. The benefit of the modeling components is investigated for the interpolation of seasonal mean and daily precipitation using leave-one-out crossvalidation. The study domain is a north-south cross-section of the European Alps (154x187 km2), which disposes of dense rain-gauge measurements (approx. 440 stations, 1971-2008).

The significance of the topographic predictors was found to strongly depend on the interpolation framework. In linear regression predictors of slope and at multiple scales reduce interpolation errors substantially. But with as many as nine predictors the resulting interpolation still poorly replicates the across-ridge variation. Kriging with external drift leads to much smaller interpolation errors than linear regression. But this is achieved with a single predictor of local height already, and the extended predictor sets bring only marginal further improvement. Again, the stratification by circulation types and the wind-aligned gradient predictor do not improve over the single predictor KED model. Similarly for daily precipitation, information from circulation types is not improving interpolation accuracy. The results confirm that topographic predictors are essential for reducing interpolation errors, but exploiting the spatial autocorrelation in the data may be as effective as developing elaborate predictor sets. Our results also question a popular practice of using linear regression for predictor selection and they support the common practice of using climatological background fields in the interpolation of daily precipitation.