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Scale-Dependence of the Precipitation-Topography Relationship in the Alpine Region

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A wide range of applications related to the Alpine climate need an accurate representation of the spatial and temporal variations of observed precipitation. A convenient basis for such applications are grid datasets derived from rain gauge measurements. However, their construction is challenged by the complexity of the Alpine topography and the small-scale nature of precipitation patterns. Moreover, because rain-gauges are unevenly distributed with height (more stations located in valleys), naive interpolation is necessarily biased. Spatial interpolation of precipitation has, therefore, to be built on a model of the precipitation-topography relationship.

In this study we examine precipitation-topography relationships in a multi-scale framework. The distribution of precipitation amounts is considered as a superposition of mechanisms acting at different spatial scales, from the regional scale of the whole ridge down to the local scale of individual mountains and valleys. To this end, multi-linear regression experiments are undertaken with comprehensive sets of topographic predictors, determined from digital elevation models at various spatial scales.

In a first step, our experiments are conducted for a quasi two-dimensional sub-section of the Alps in western Austria and southern Germany. Climatological mean precipitation for the period 1971-1990 from about 410 stations is used as predictand. The station observations were taken from a trans-Alpine dataset that was collected in the framework of EURO4M. The topographic predictors are constructed from the Shuttle Radar Topography Mission dataset (SRTM, 250 m resolution) and smooth versions of it were obtained by kernel filtering at various scales up to 75 km. Using a stepwise selection based on the Akaike information criterion, we find that a linear model combining the topographic effects of several spatial scales can explain about 70% of the climatological precipitation variability. Our preliminary results indicate that explicit modeling of the coarse-scale component has a relevant influence on the fine-scale model component. The implication of these findings for the spatial interpolation of rainfall will be discussed.