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From single estimates to ensembles: Quantifying uncertainties in spatial precipitation analyses over the Alps

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There is a growing awareness that uncertainties in spatial climate analyses may be considerable. Therefore, professional use of spatial data products calls for an assessment of the significance of interpolation errors in applications. Unfortunately, traditional measures of uncertainty, such as cross-validation statistics, are of limited use here. They are summary statistics, i.e. of limited representativity for a concrete use case, and they represent errors at the point scale only, i.e. are not informative for spatial aggregates. The lack of comprehensive uncertainty information is a major obstacle in the application of grid datasets, particularly for the evaluation of climate models and re-analyses.

In this study we propose a probabilistic spatial analysis of daily precipitation that is capable of quantifying uncertainties explicitly on a day-by-day basis, in relation to local rain-gauge density, and as a function of the spatial averaging scale. In our presentation we introduce, illustrate and rigorously test the technique in an application over 400 nested hydrological units and with data from several thousand rain gauges in the entire Alpine region.

The probabilistic spatial analysis builds on the stochastic concept of trans-Gaussian random fields. Rather than predicting a single field (a conditional expectation), like is common in kriging, our method simulates random realizations conditioned on the available observations (a conditional ensemble). The uncertainty of model parameters is taken into account by turning to Bayesian inference. The results of our application point to remarkable variations in the magnitude of uncertainty. It is larger for convective compared to stratiform situations, it increases with decreasing density of observing stations, and it decreases with the size of the wet area in the catchment. Tests hint to the quantitative reliability/consistency of the magnitude of uncertainties.

Ensemble spatial precipitation analyses permit for a scale-dependent evaluation of climate models that is much less confounded by representativity errors than conventional comparison against single estimates.