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Using Bayesian geostatistical models to correct gridded hydrological products relative to the actually observed streamflow

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Conceptual hydrological models are process-based models that are used to simulate flow indices based on physical or empirical relationships and input variables like precipitation, temperature and land use. For many applications the goal is to use the process-based model to construct a gridded map of the flow index of interest, e.g. for mean annual runoff. However, one challenge is that the resulting runoff map does not necessarily fit to the actually observed streamflow data when the grid nodes are aggregated to catchment areas. A solution to this problem is to correct the gridded hydrological product afterwards relative to the actually observed streamflow in areas where we have measurements. In this work, we explore different Bayesian geostatistical tools that can contribute to this correction. We suggest a model where the observed streamflow is used as a response variable and the gridded hydrological product is used as a covariate. In particular, a geostatistical model with a spatially varying coefficient (SVC) is suggested, and we develop a linear relationship between the response and the covariate that is allowed to vary in the study area. This is achieved by modeling the regression coefficient as a Gaussian random field (GRF) that defines the spatial pattern of the linear relationship. We also test two simpler geostatistical models, and investigate how short records of runoff can be included in the correction procedure.

The geostatistical models are tested by correcting a gridded mean annual runoff product from the HBV model relative to the observed mean annual runoff. We use data from around 400 catchments in Norway from 1981-2010. The results show that all three geostatistical methods lead to a considerably better fit between the corrected product and the actually observed streamflow for the gauged catchments, which was our main goal. In addition, we also obtain improved predictions for many of the ungauged catchments in Norway.