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Optimization of rain gauge sampling density for discharge prediction using Bayesian calibration

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Stream discharges are often predicted based on a calibrated rainfall-runoff model. The major sources of uncertainty, namely input, parameter and model structure uncertainty must all be taken into account to obtain realistic estimates of the accuracy of discharge predictions. Over the past years, Bayesian calibration has emerged as a valuable method to quantify uncertainty in model parameters and model structure, where the latter is usually simplistically modelled by an additive or multiplicative stochastic term. Much work has also recently been done on including input uncertainty in the Bayesian framework. However, studies that included rainfall input uncertainty did not employ geostatistical methods to characterize the prior distribution of the overall catchment rainfall and did not consider how an increase or decrease of the rain gauge network density influences the discharge prediction accuracy. In this presentation we integrate geostatistics and Bayesian calibration to analyse the effect of rain-gauge density on discharge prediction accuracy. We calibrated the well-known HBV hydrological model while accounting for input, initial state, model parameter and model structure uncertainty, while also taking uncertainties in the discharge measurements into account. Results for the Thur catchment in Switzerland show that (i) an increase of the rain gauge density leads to a decrease of input uncertainty, but (ii) further increase of the rain-gauge density (larger than 1 gauge/170 km^2) does not lead to improvement of the total error. We also show that a low rain-gauge density does not necessarily lead to biased predictions, provided that the major sources of uncertainty are explicitly accounted for and that large input uncertainty can be safely lumped into parameter uncertainty.