Rainfall estimation using a non-stationary geostatistical model and uncertain measurements

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Accurate areal rainfall estimation at high spatio-temporal resolution is important in numerous urban and rural hydrological and water quality applications. Merging radar rainfall estimates and point measurements from rain gauges is recognized to improve the accuracy. Nevertheless, a residual uncertainty remains, due to both rain gauge measurement uncertainty and radar estimation uncertainty. The non-stationarity of radar and rain gauge uncertainty is significant and should be included in the merging algorithms. Over the past years, substantial progress has been made to deal with non-stationary spatial processes in kriging. Various well-documented geostatistical models relax the assumption of stationarity in the mean, while recent studies show the importance of considering non-stationarity in the variance. In this study, we include non-stationarity in the mean and variance, as well as point measurement uncertainty and radar uncertainty using a relatively simple extension of the Kriging with External Drift (KED) model for estimation of rainfall fields. The non-stationarity in the mean and variance are modelled as functions of external covariates, such as radar imagery, distance to radar antennas and radar beam blockage. The model is associated to a Kriging for Uncertain Data (KUD) approach that takes account of point measurement uncertainty. The model is tested using a case study near Manchester in the United Kingdom for five events. Rain gauge data are obtained from the Environment Agency 0.2 mm tipping bucket rain gauge network, while the radar data is from the Met Office 1 km by 1 km 5-minute radar mosaics. Tipping bucket rain gauge uncertainty is quantified using a random error model. The probabilistic rainfall estimates are validated against independent rain gauge measurements on the selected events. Results show that the proposed model improves both the rainfall estimation mean and the variance, as compared to non-corrected radar estimates or to standard KED merging results.

KEYWORDS

Radar-rain gauge merging, kriging with external drift, non-stationary variance, kriging for uncertain data, rain gauge error model