Geophysical Research Abstracts
Vol. 20, EGU2018-8740-2, 2018
EGU General Assembly 2018

Radar-gauge data merging with uncertainty: Kriging with External Drift and Non-Stationary Variance (KED-NSV)

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Merging radar data Quantitative Precipitation Estimation (QPE) with rain gauge measurements is recognised to improve the accuracy of rainfall estimates. Despite the improved accuracy, merged precipitation products are still affected by residual uncertainty. The aim of this work was to present and analyse a methodology to merge radar QPE and rain gauge measurements taking into consideration the factors that affect radar uncertainty. Kriging with External Drift (KED) was modified to account for non-stationarity of the process variance, leading to Kriging with External Drift and Non-Stationary Variance (KED-NSV). The standard KED formulation accounts for a non-stationary mean and models this as a linear function of the radar QPE. We expanded KED to account for a non-stationary variance as well, analogously modelling the standard deviation of the underlying random process as a linear function of covariates that affect the spatial variation of radar uncertainty. Five covariates that can potentially influence the spatial uncertainty of radar QPE were considered: 1) static clutter map, 2) digital elevation model (DEM), 3) map of distance from the nearest radar station, 4) interpolated average absolute residual between radar and rain gauge rainfall estimates, and 5) rainfall intensity as estimated by the QPE. The aim of the work was to understand how beneficial the KED-NSV formulation is both in terms of prediction and uncertainty estimation, compared to standard KED, and to evaluate which and how many covariates should be included in the model. A step-wise approach was taken, by adding covariates to the model one by one until no significant improvement of the model fit was obtained. Results show that the use of one static covariate, especially using the DEM and the average rainfall residuals, improves rainfall estimations as compared to the stationary-variance model, but increasing the number of covariates does not clearly produce further improvement in estimating rainfall. As concerns rainfall uncertainty estimation, it was shown that the comparison between KED and KED-NSV results is overshadowed by the unrealistic Gaussian distribution produced by kriging, which is not appropriate for hourly rainfall.