Geostatistical upscaling of rain gauge data to support uncertainty analysis of lumped urban hydrological models

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Introduction

Problem

- Number of deterministic interpolation methods are used in practice to estimate areal average rainfall intensity (AARI) from point observations
  - e.g. Arithmetic average , Nearest neighbor interpolation
- Major drawback - No information on the uncertainty of the estimation
- Main sources of uncertainty - measurement errors and spatiotemporal variability

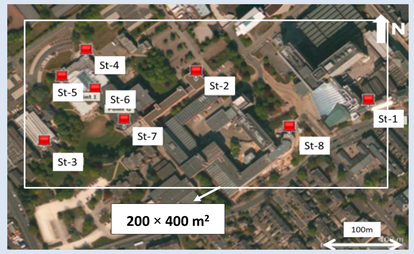
Potential solution and challenges

- Geostatistical methods provide a measure of prediction error
- Main challenges of geostatistical methods
  - Inherent complexity and large data requirement, and
  - Normality of data – rainfall data are almost never normally distributed

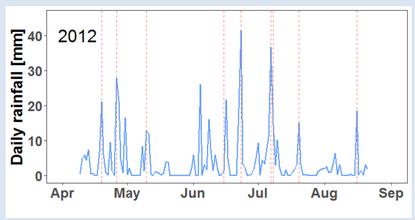
Aim

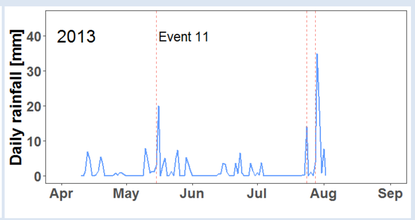
- To employ a geostatistical approach to derive AARI and the level of uncertainty associated with it by presenting solutions to the above-described challenges

Data collection



Site	Bradford University, UK
Rain gauge type	Tipping bucket (0.2mm)
Temporal resolution	1 min
Selected events	13 (vertical dotted lines)



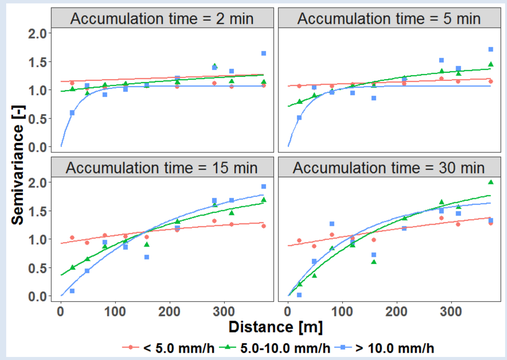


Method

1. Pooling of sample variograms of time instants using predefined range of rainfall intensities, r (< 5mm/hr, 5-10 mm/hr & > 10 mm/hr)
2. Standardisation of rainfall intensities, $\tilde{r} = S(r)$
3. Normal score transformation of standardised intensities, $r_N = NST(\tilde{r})$
4. Calibration of geostatistical model for r_N in the form of a variogram
5. Spatial stochastic simulation producing a large number of realisations of r_N
6. Back-transformation of all realisations using NST^{-1}
7. Spatial aggregation of each of the back-transformed simulations
8. Estimation of the mean prediction (mean of the aggregates) and standard deviation (standard deviation of the aggregates)
9. Inverse standardisation of mean prediction (=AARI) and standard deviation (uncertainty measure) using S^{-1}

Results and discussion

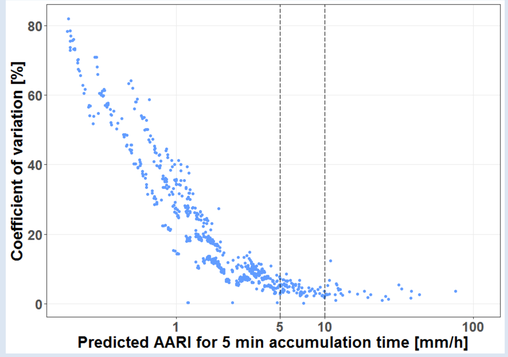
Variograms



For short time and small space scales the use of a single geostatistical model based on a single variogram is not appropriate and a distinction between rainfall intensity classes and accumulation time should be made.

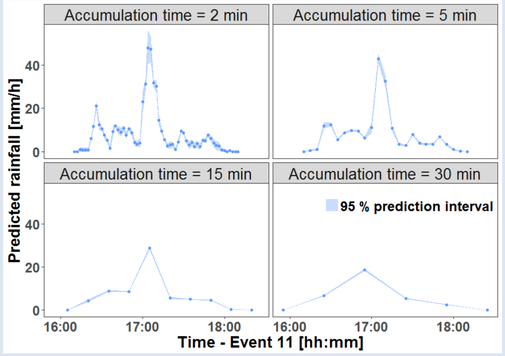
The significance and characteristics of the measurement error observed in variograms (nugget) mainly corresponds to sampling related error of tipping bucket type rain gauges (TB error).

Uncertainty vs AARI



TB error decreases with increasing rainfall intensity. As a result of that, the prediction error decreases with increasing AARI. Spatial variability does not show any clear trend against intensity.

Uncertainty vs accumulation time



At smaller accumulation time, the effect of both spatial variability and TB error is high, resulting in higher uncertainty levels in the prediction of AARI. With increasing accumulation time the uncertainty becomes smaller.

Remarks

Although spatial stochastic simulation used in this study needs more computational power than block kriging, it is a robust approach and allows data transformation during spatial interpolation to make the data normally distributed.

The pooling procedure used in this study makes use of the continuous measurement of rainfall and helps provides a solution to meet the data requirements for many geostatistical interpolation methods to a certain extent.

Results from this study can be used for uncertainty analyses of hydrologic and hydrodynamic modelling of similar sized urban catchments in similar climates as it provides information on uncertainty associated with rainfall estimation.

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Citation: Muthusamy, M., Schellart, A., Tait, S., and Heuvelink, G. B. M.: Geostatistical upscaling of rain gauge data to support uncertainty analysis of lumped urban hydrological models, Hydrol. Earth Syst. Sci., 21, 1077-1091, doi:10.5194/hess-21-1077-2017, 2017.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 607000.