Uncertainty Quantification of Theoretical Consistent Intensity Duration Frequency (IDF) Curves of Rainfall Intensity

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Step wise Procedure of Implemented CGS Approach

1) Establish grid network & coordinate system
2) Assisgn data to grid
3) Transform data to normal space
4) Calculate the semi-variogram

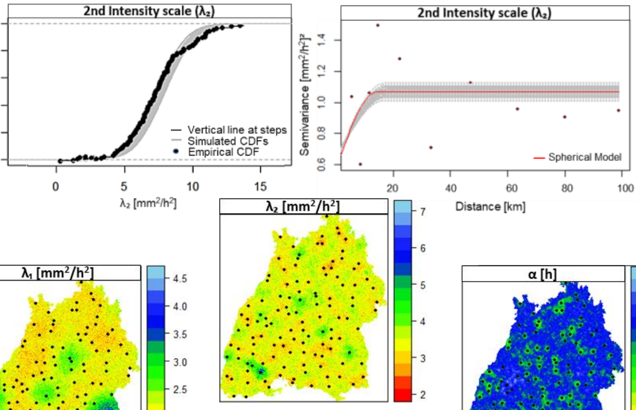
Loop over Realizations

5) Determine a random path through all grid nodes, at each node:

Loop over model nodes

a) Find nearby data & previously simulated grid nodes
b) Construct the conditional distribution by kriging
c) Drew simulated value from conditional distribution
d) Assign the simulated value to the grid as data

6) Check all the realizations after back transformation
7) Back transform from original space



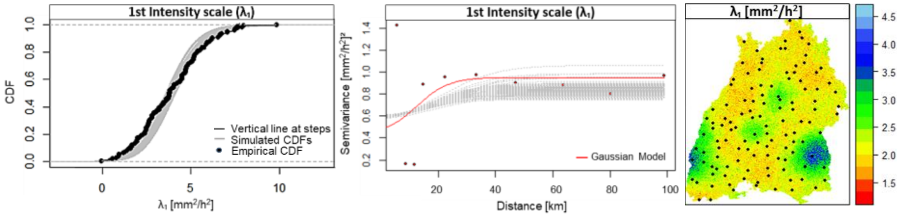
Final Thoughts & Future Intentions

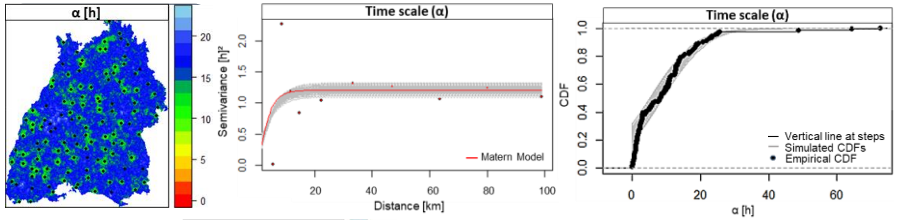
Overall, integration of local resampling and CGS provided accurate uncertainty quantifiication in regionalization of IDF model parameters

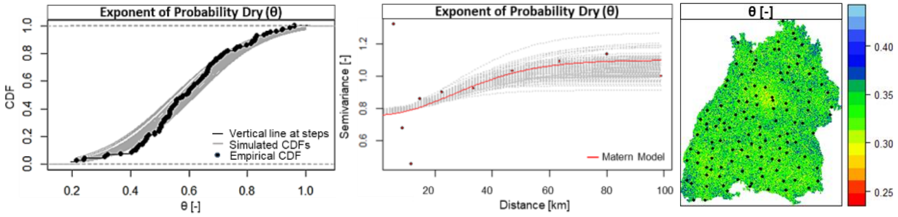
Only considering local uncertaintly will lead to underestimation of total uncertainty especially at very short duration interval and high return periods

Narrower uncertainty ranges (95% CI) are observed when retrieving rainfall IDFs by applying method of Koutsoyiannis (2021) which also ensures higher accuracy

Instead of only considering sample & spatial variability for uncertainty estimation Furure work will focus on non-staionarity due to cliamte change & uncertainty pattern variations

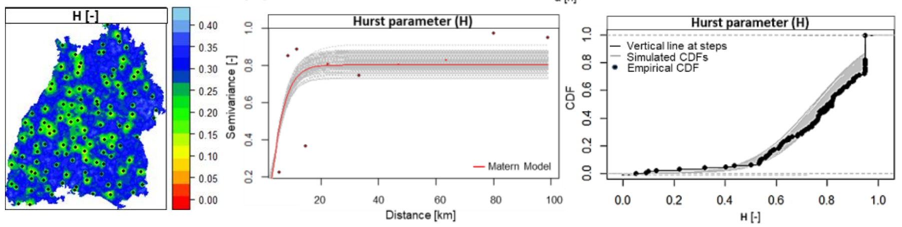


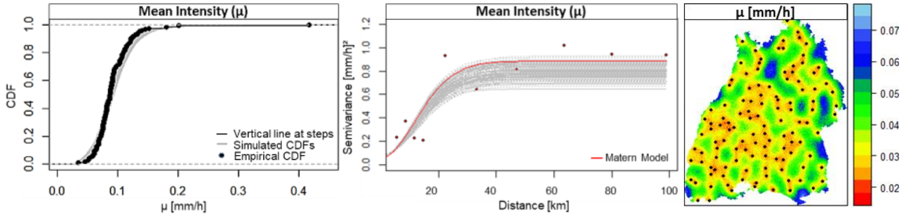


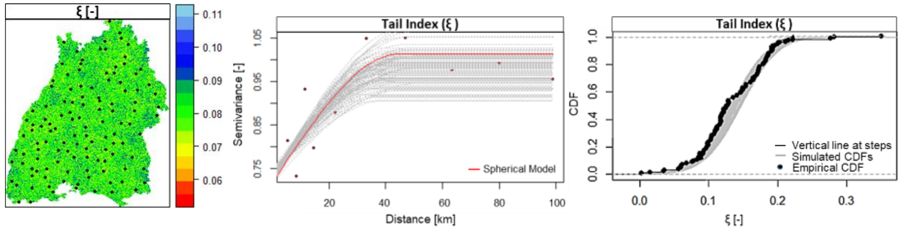


Param.	Mean	Std. Err.	LB_95%CI	UB_95%CI
μ	0.0906	0.0034	0.0840	0.0972
θ	0.5793	0.0164	0.5471	0.6115
λ₁	0.5456	0.1631	0.2260	0.8652
λ₂	1.2795	0.1990	0.8895	1.6695
α	6.1391	0.9502	4.2766	8.0015
H	0.7965	0.0163	0.7646	0.8284
ξ	0.1348	0.0039	0.1272	0.1425

parameters in terms of 95% Confidence Interval







Importance

Many water-related systems and defensive structures require the design of rainfall amounts at various durations and frequencies, commonly referred to as Intensity Duration-Frequency (IDF) curves

Usually, these curves are derived from observed data, but there is a chance that the risk has been underestimated because of various uncertainty sources. Thus, measuring the uncertainty ranges using a mixture of spatial Conditional Sequential Gaussian Simulation and local bootstrap resampling of these curves becomes essential.

Conditional

The simulations are conditional on observed data, meaning that simulated values at sampled locations are set to observed values. This ensures that each realization is consistent with observed data. The pre-existing data points are used as condition for the model to generate simulations. Sequential Inclusion of simulated values impose correct spatial correlation b/w simulated values

Gaussian

The simulations aim to reproduce histogram (frequency distribution of observed data). This is typically ensured by drawing the simulated values from a Gaussian distribution, as this is a commonly observed distribution in natural phenomena. Since local conditional distribution shape is known and can be parameterized by mean (Kriging estimate) and estimated variance.

Simulations

Simulation through Monte Carlo simulation from the local distribution of uncertainty to add in missing variance and construction of multiple, equiprobable realizations.
The uncertainty is estimated based on the experiment simulations using following criteria:

$$95\%\ CI = \frac{(x_{97.5\,\%} - x_{2.5\,\%})}{\bar{x}}$$

1.Respect for observed data:

2. Replication of statistical properties:

3. Replication of spatial correlation: