Synthesis of rainfall timeseries in a high temporal resolution – a parametric approach

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1. Motivation & Objectives

- Design and operation of urban drainage systems require **long and continuous** rain series.
- *Problem*: Short data availability (temporal and spatial required resolutions).
- *Solution*: Development of a **precipitation model** and generation of long synthetic series (Haberlandt *et al.*,2008).
  - Time resolution: **5 min**
  - Spatial resolution: **1Km x 1Km**

2. Methodology

a) Definition of rainfall events:

Variable	Unit	Description	Minimum
DSD	min	Dry Spell Duration	5
WSD	min	Wet Spell Duration	-
WSTpeak	min	Time to peak	-
WSA	mm	Wet Spell Amount	1.00
WSI	mm/min	Wet Spell Intensity	0.002
WSPeak	mm/5min	Wet Spell Peak Intensity	-

b) Analysis of external structure (Fig. 1);

c) Analysis of internal structure (Fig. 2);

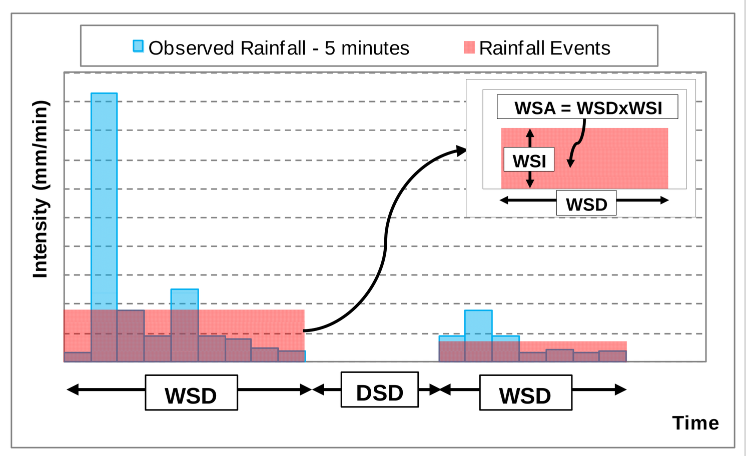

Figure 1: External structure of events.

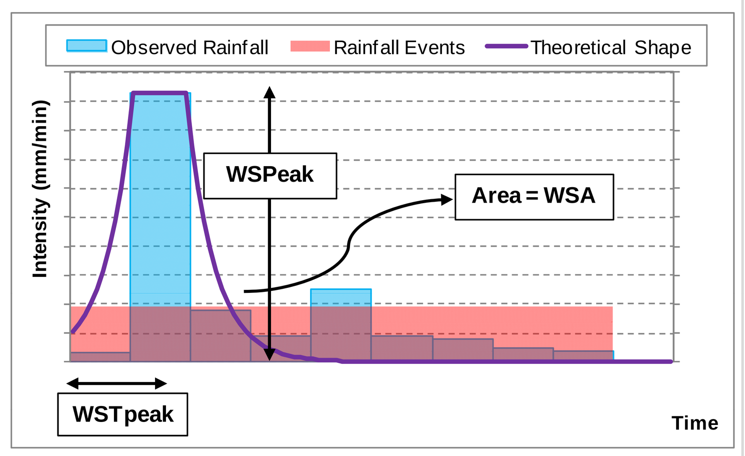

Figure 2: Internal structure of events.

d) Regionalization of parameters:
- Interpolation methods: ID (Inverse Distance) , OK (Ordinary Kriging), EDK (External Drift Kriging)
- Consideration of correlation between parameters

e) Cross-Validation:
- Precipitation model
- Simulation of floodings using fictional urban cases – SWMM (Storm Water Management Model, EPA)

3. Study Area & Data

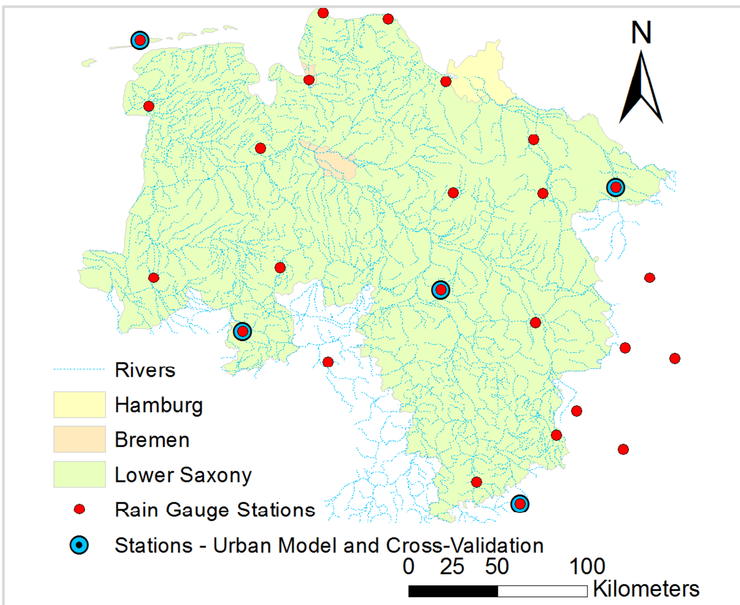

Figure 3: Location Rain Gauge Stations.

- State of **Lower Saxony**
  - Surface: 47,624 km^2,
  - Location: North-west Germany.
- **Rainfall** measurements:
  - 25 stations (Fig. 3),
  - 10-20 years of record ,
  - 5 minute time resolution.

4. Results

- Considered models

Model	DSD	WSD	WSA	WSI	Bivariate model	
WSI_2*Ncop	Pearson 3	Generalized Pareto	f(WSI,WSD)	Generalized Pareto	WSI-WSD	1 per season
WSI_Ncop						1 per year
WSI_1cop						1 for all stations
WSA_2*NCop			Kappa	f(WSA,WSD)	WSA-WSD	1 per season
WSA_Ncop						1 per year
WSA_1cop						1 for all stations

- Bivariate models

WSI-WSD:
Normal Copula
Kendall's Tau (mean):**-0.43**

WSA-WSD:
Hüsler-Reiss Copula
Kendall's Tau (mean): **0.38**

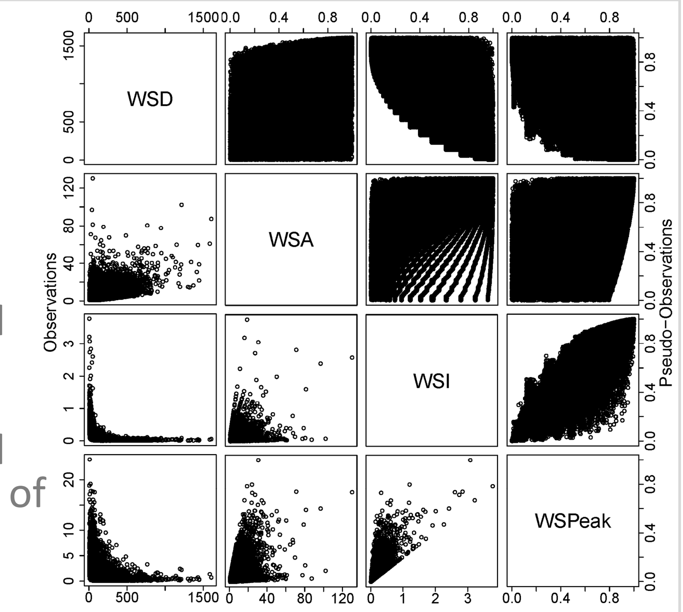

Figure 4: Pairs of observed and pseudo-observed variables of the 25 stations.

- Validation of the precipitation model

*Error (%) = [Synthetic – Observed]*100/Observed*

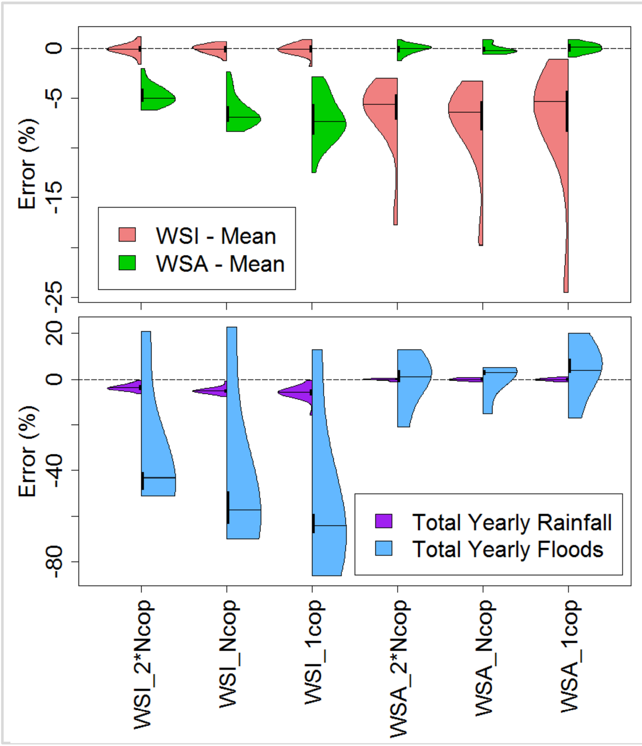

Figure 5: Error in simulating some basic statistics, total yearly rainfall and floodings.

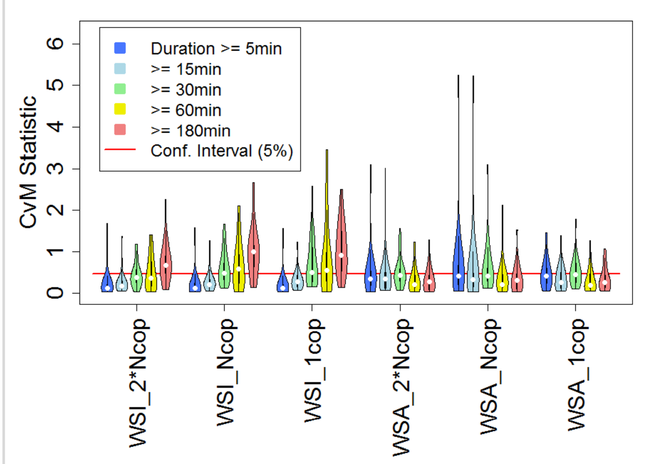

Figure 6: Test of fit: synthetic vs. observed extreme values series.

- Parameters regionalization

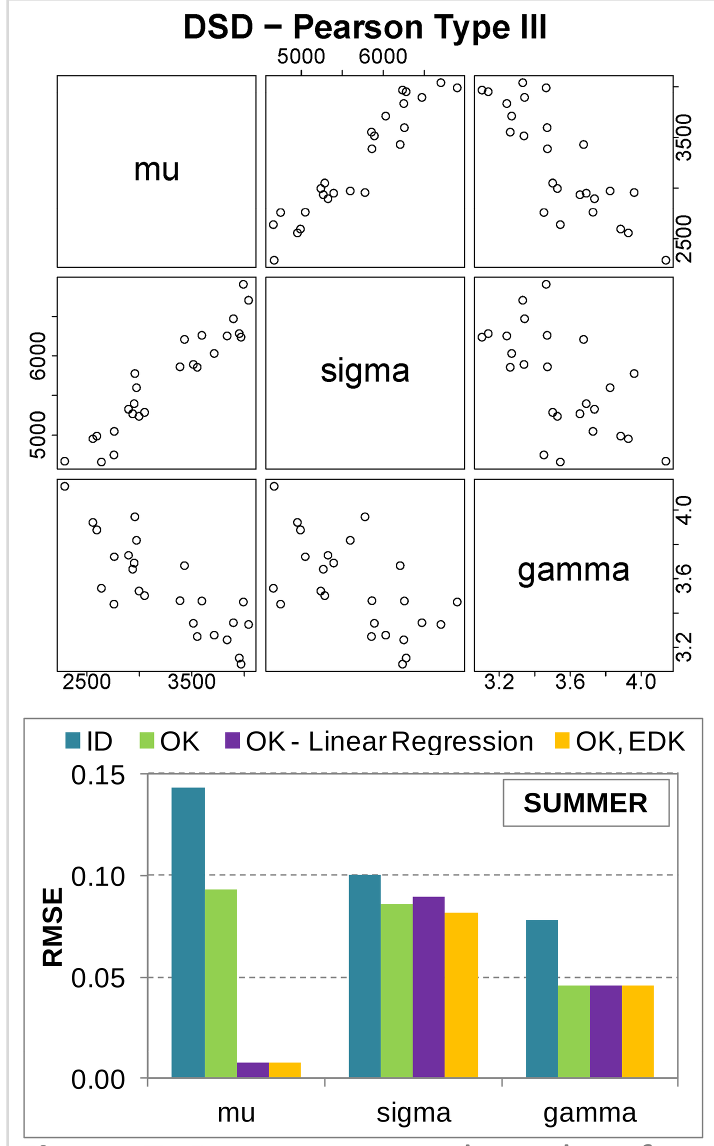

Figure 7: Parameters and results of different interpolation techniques: DSD Summer events.

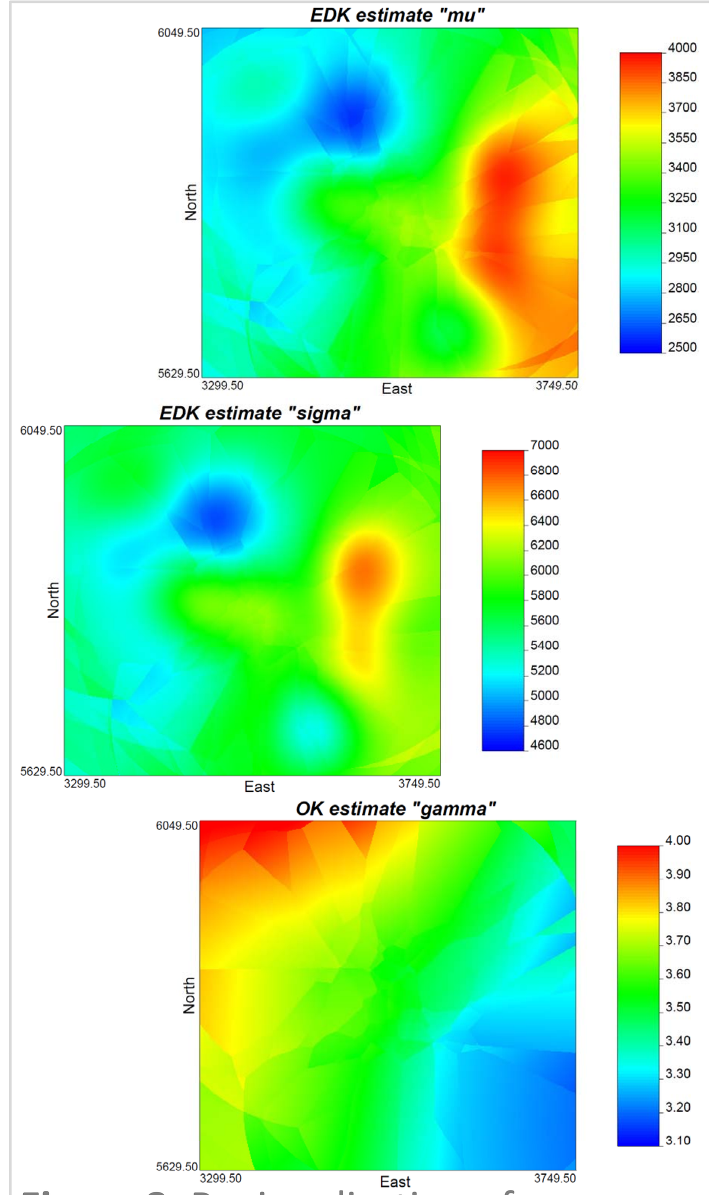

Figure 8: Regionalization of parameters: DSD Summer events.

- Cross-Validation

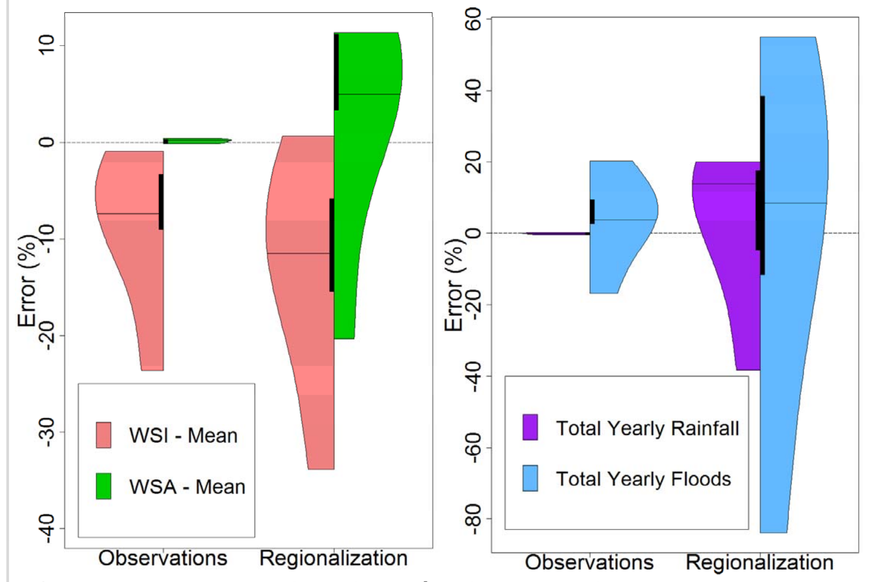

Figure 9: Error in simulations using parameters derived from observations and regionalization.

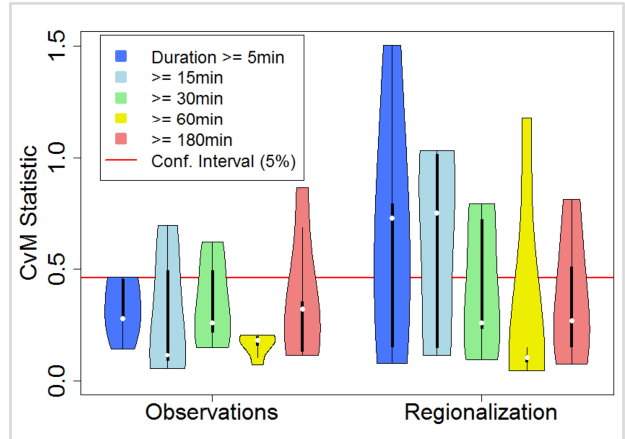

Figure 10: Comparison of test of fit for extreme values.

5. Summary and Conclusions

- Selected Model: Generation WSA with 1 copula parameter for all stations;
  - Good performance in reproducing WSA and total yearly rainfall
  - Best performance in reproducing Extreme Values
  - Competitive performance in reproducing flood events.
- Interpolation: Including correlation improves results;
- Cross-Validation: Acceptable for some variables.

References: Haberlandt, U., Ebner von Eschenbach, A.-D., and Buchwald, I. (2008): A space-time hybrid hourly rainfall model for derived flood frequency analysis, Hydrol. Earth Syst. Sci., 12, 1353-1367, doi:10.5194/hess-12-1353-2008.

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