Generation of future high-resolution rainfall time series with a disaggregation model

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1 Motivation

- **Future rainfall time series** are important for **rainfall-runoff modeling** and derived **flood frequency analysis**
- Time series of **climate models** show **high uncertainties**
- Alternative: **Rainfall time series generation** with a **cascade model**
- ⇨ Aim: **Generation of future high-resolution rainfall time series**

2 Study area & data

- **Lower Saxony** with **5 recording rain gauges** (Fig. 1)
  → Time series length 18 – 20 yrs
- Related **REMO raster cell time series (3 realisations)**, 10 x 10 km
  → C20 (1971-2000), short (2021-2050) and long-term (2071-2100) future

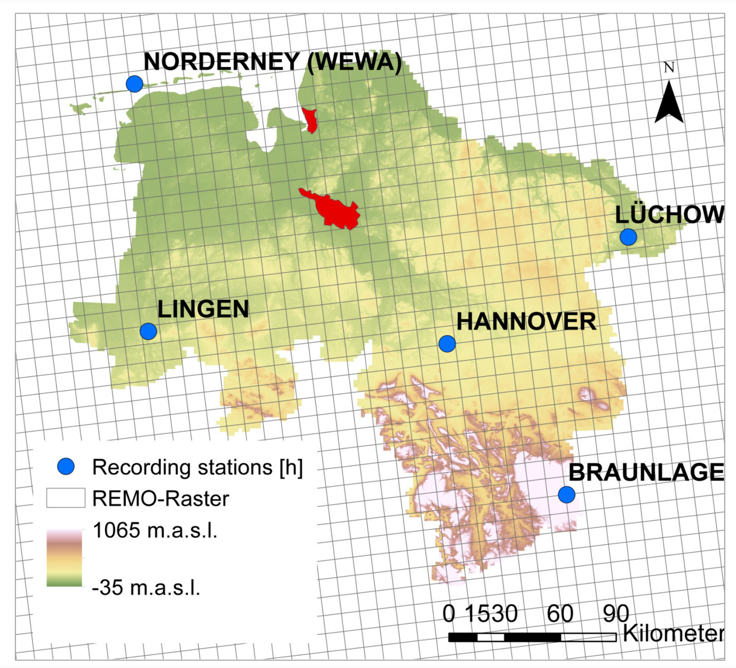


Fig. 1: Lower Saxony with recording stations and REMO raster data

3 Analysis of REMO data

- **Comparison** of station and REMO data → **Observation vs. C20** (Table 1)

Table 1: Comparison of rainfall characteristics of observed and REMO time series for station Norderney

Data origin	Wet spell duration *wsd* [h]	Wet spell amount *wsa* [mm]	Dry spells *dsd* [h]	Frac. dry intervals P_0 [%]	Average intensity *AvInt* [mm/h]
Observation	2.8	1.8	22.0	88.9	0.7
REMO-BFG	5.0	2.1	13.9	73.6	0.4
REMO-ENS	7.6	1.9	8.7	53.4	0.2
REMO-UBA	4.8	2.2	15.2	76.0	0.4

- **Comparison** of rainfall characteristics in **C20, near- and long-term future** (Table 2 & Fig. 3)

Table 2: Changes of rainfall characteristics (x_i>4 mm, Bias in [%], Hanover)

		REMO-BFG	REMO-ENS	REMO-UBA
Near-term	*wsd*	1.9	0.8	1.5
	wsa	4.7	-3.3	-0.2
	dsd	-6.2	-9.4	-13.1
	P_0	0.0	0.0	0.0
	AvInt	2.8	-4.0	-1.7
Long-term	*wsd*	9.1	2.7	9.0
	wsa	10.6	8.1	6.0
	dsd	-9.2	-21.2	-10.9
	P_0	0.0	0.0	0.0
	AvInt	1.4	5.3	-2.8

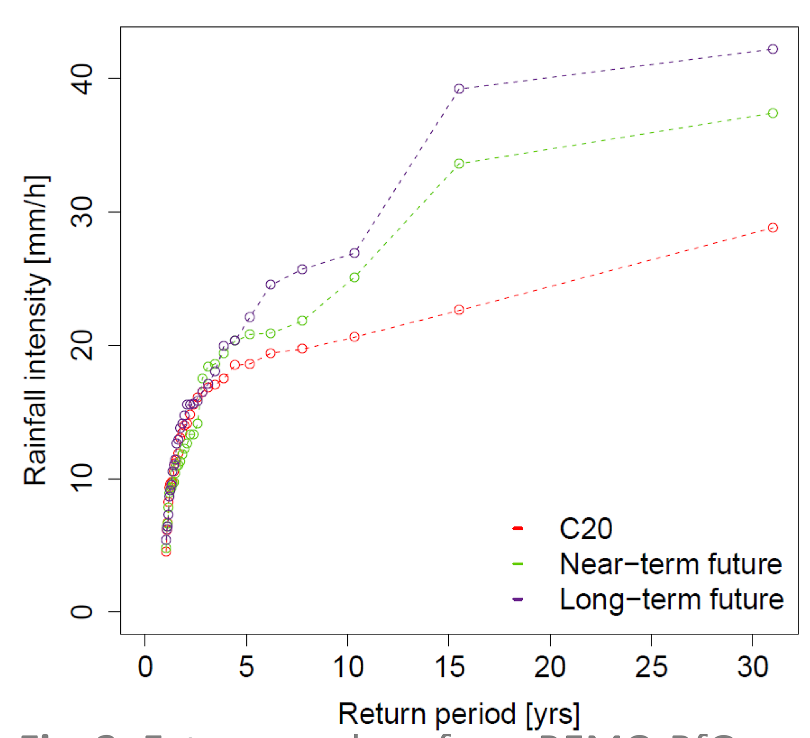


Fig. 3: Extreme values from REMO-BfG, for station Hanover

4 Disaggregation model

- Disaggregation with a **multiplicative cascade model** according to Müller & Haberlandt (2015) (Fig. 2)

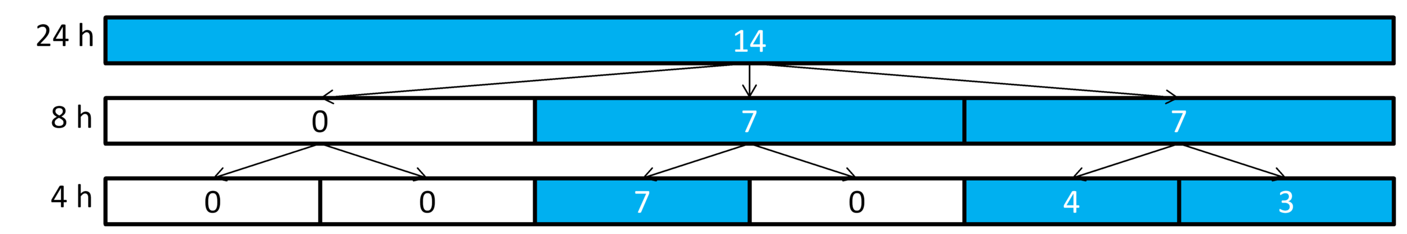
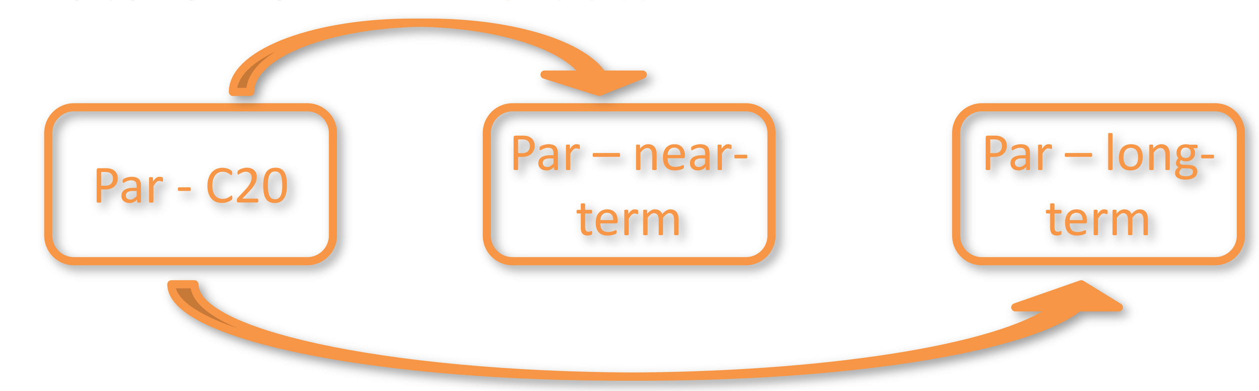


Fig. 2: Scheme of the cascade model with a branching number of b=3 in the first disaggregation step and b=2 for all further steps to achieve a temporal resolution of Δt=1 h

- Parameter for **b=3**: P(1/0/0), P(½/½/0), P(⅓/ ⅓/ ⅓)
  → for two volume classes
- Parameter for **b=2**: P(1/0), P(0/1), P(x/(1-x)), F(x)
  → for four position and two volume classes
- **Parameter** can be **estimated** directly from high-resolution time series **by aggregation**
- Parameter are **interpretable in a physical way**

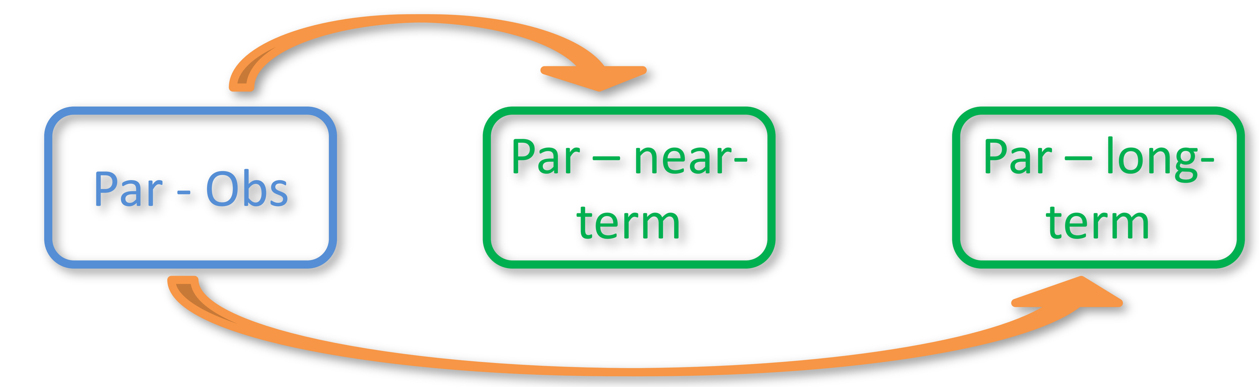
5 Climate change implementation

- Estimation of cascade model parameters (Par) for C20-period, near- and long-term future from REMO data



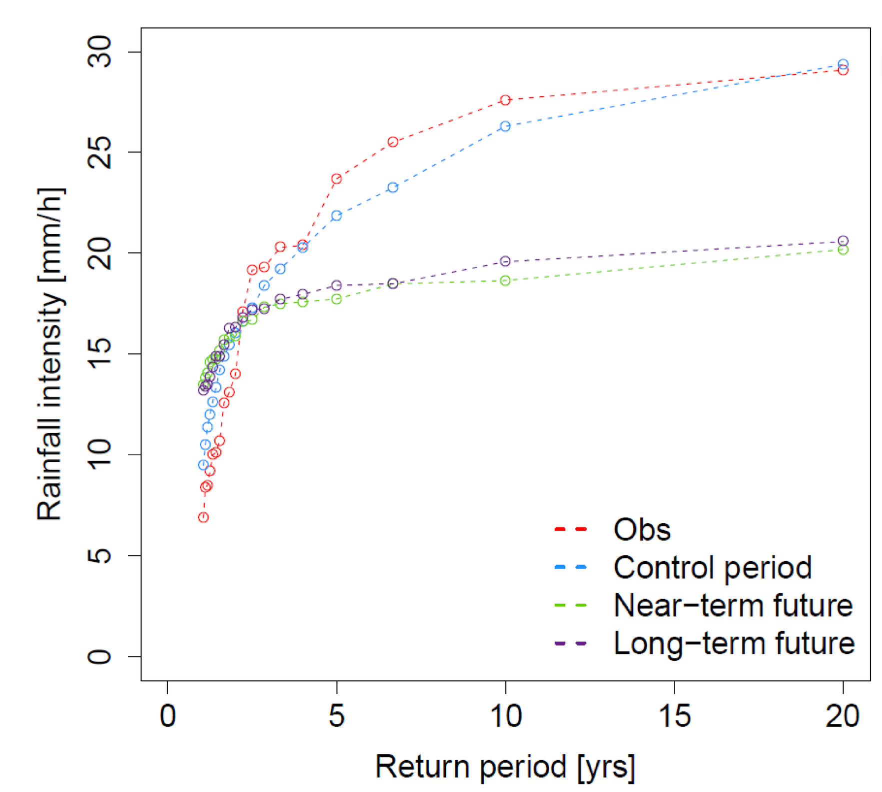
Identification of parameter changes ΔPar

- Adding of ΔPar to parameters from observed time series → future parameter



6 Results

- **Unrealistic rainfall extremes** are generated for future periods (Fig. 4)
  → in comparison to control period (with parameters only estimated from observed time series)



- Main reason: **Parameter differences** for first splitting with **b=3** (Table 3):
  → P(⅓/ ⅓/ ⅓) is overestimated by the REMO data for the upper volume class

Fig. 4: Extreme values of the disaggregated time series with observed (control period) and by REMO influenced parameters (BfG, Hanover)

Table 3: Parameters for b=3 in dependence of the analyzed data set (Norderney)

	Lower volume class			Upper volume class		
	P(1/0/0)	P(½/½/0)	P(⅓/ ⅓/ ⅓)	P(1/0/0)	P(½/½/0)	P(⅓/ ⅓/ ⅓)
Station	40	36	24	0	63	38
REMO	30	33	37	0	18	82

7 Summary & Outlook

- Climate changes in REMO are **not robust**
- **Parameter** from REMO and stations **differ significantly for b=3, less for b=2**
- Parameter for splitting with b=3 are of **major importance** for the generation of **extreme values**
- **Differences** for b=3 result **from spatial resolution** of the data sets
- Possible solutions:
  - ⇨ **Spatial downscaling** of REMO data & subsequent parameter estimation
  - ⇨ **Bias correction** of the parameter estimated from REMO

References

Müller, H., Haberlandt, U. (2015): Temporal rainfall disaggregation with a cascade model: from single-station disaggregation to spatial rainfall, J. Hydrol. Eng, ISSN (print): 1084-0699

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