Universität Stuttgart

Modeling Climate Change Impacts on Storm Water Overflow using Simulated Precipitation Time Series

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The Project - KliWaMi

financed by the Ministry of the Environment, Climate Protection and the Energy Sector

Goals

- Simulate possible effects of climate change on overflow patterns
- Test of the precipitation generator NiedSim-Klima

Method

- Long-term simulation (KOSIM) using different sewer systems
- Synthetic precipitation time series generated with NiedSim-Klima
- Several locations across Baden-Wuerttemberg to account for different precipitation pattern

Precipitation Data

Climate Station		Alltitude	Precipitation	Evaporation	Time		
Name	ID	[m.a.s.l.]	[mm/a]	[mm/a]	Start	End	Years
Wuestenrot Neuhuetten	2	473	972	612	1978	1991	14
Karlsruhe	3	**112**	767	649	1954	1990	37
Dobel Eyachmuehle	4	491	**1051**	649	1974	1991	18
Wildbad Lehenkopf	5	**847**	969	649	1974	1989	16
Holzgerlingen Altd.-Schnapseiche	6	513	710	596	1977	1992	16
Holzgerlingen Altd.-Falkenkopf	7	460	**630**	596	1977	1992	16
Schoemberg-Stausee	8	638	751	596	1977	1992	16

Time periods:

NSK1990 - 1961-1990

NSK2050 – 2041-2050

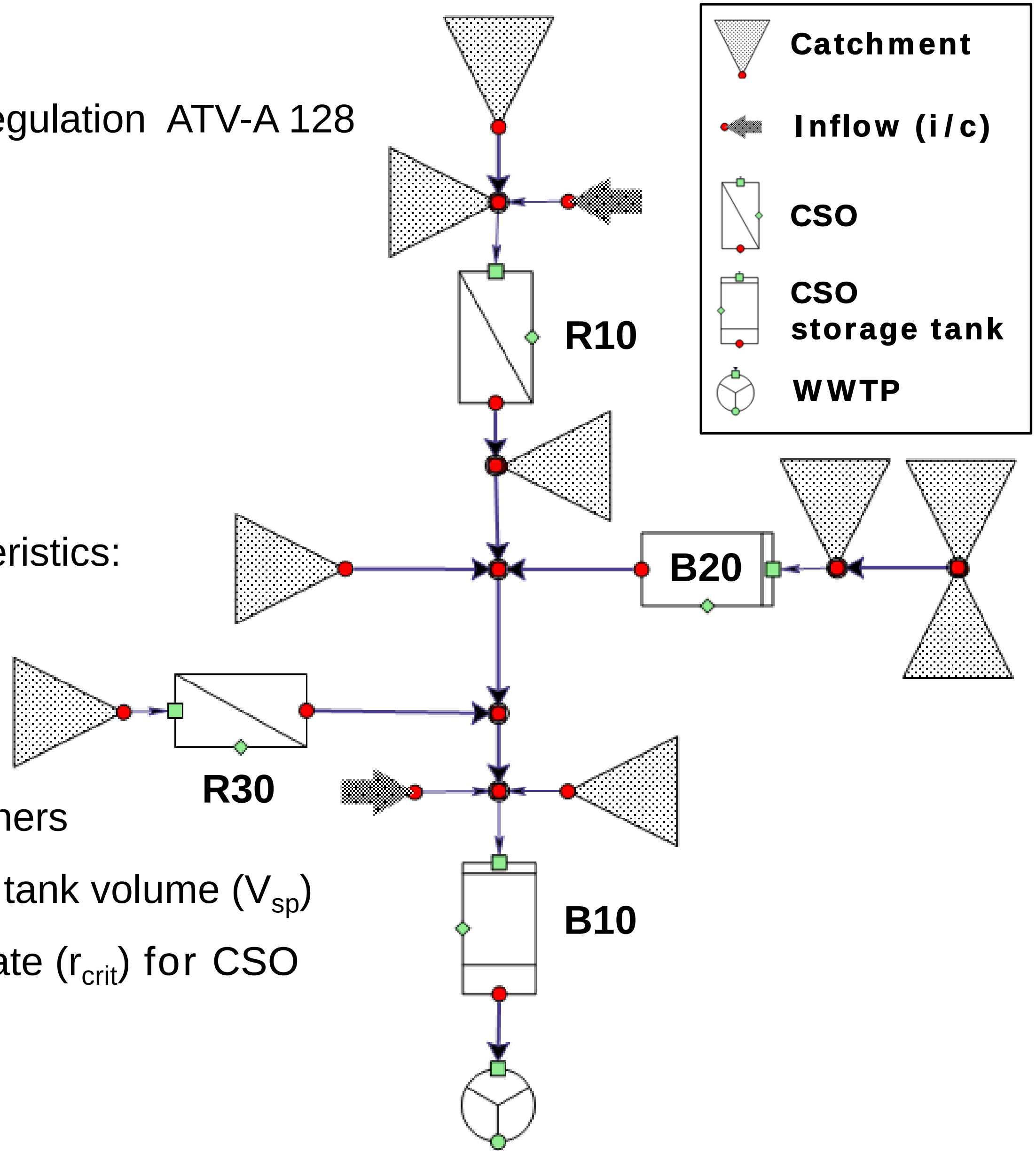
Sewer System

Ideal CSS based on the Germany regulation ATV-A 128

1. 9.900 residents
2. $A_{i,tot}$ = 102 ha
3. r_{crit} = 15 l/s·ha_{Ai}
4. V_{sp} = 10 – 19 m³/ ha_{Ai}
5. Q_{WWTP} = 167 l/s

Two real CSS with different characteristics:

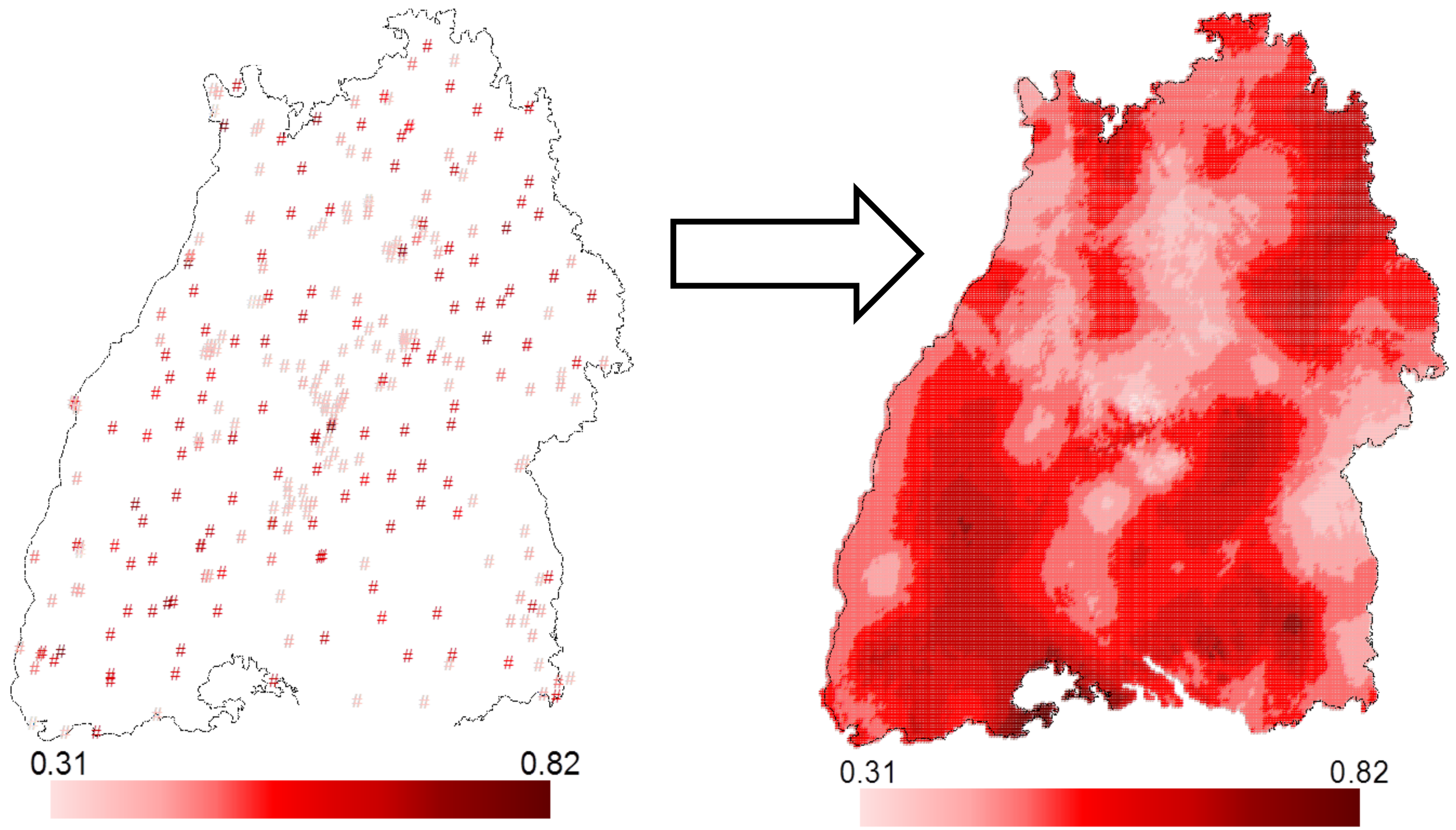
1. Size (residents, area)
2. Type (CSS/SSS/MSS)
3. Type and amount of CSOs, CSO storage tanks, and others
4. Area-specific CSO storage tank volume (V_{sp})
5. Area-specific flow control rate (r_{crit}) for CSO
6. Amount of infiltration water



NiedSim-Klima based on NiedSim

created by IWS, University of Stuttgart

- Statistical analysis of precipitation measurements of approx. 900 time series (temporal resolution: 5 min to 1 d)
- 1 km x 1 km regionalization of statistical properties (External Drift Kriging)



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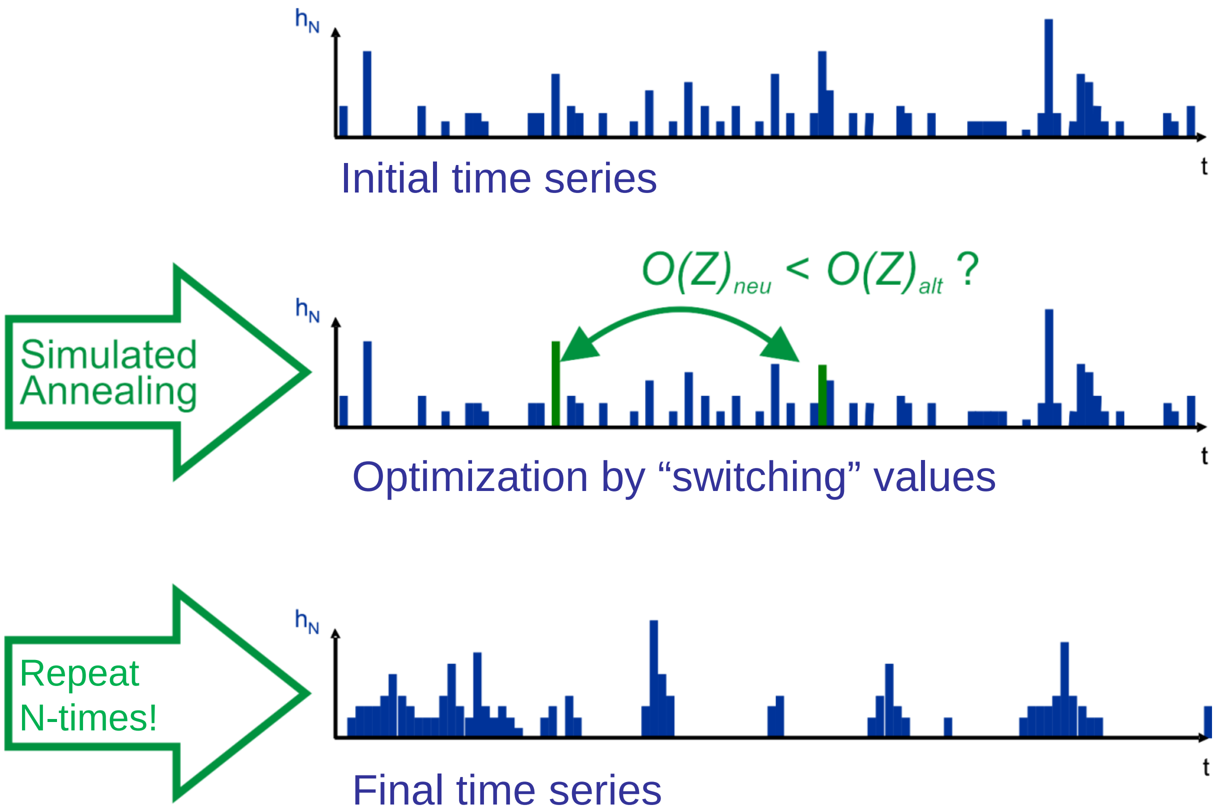
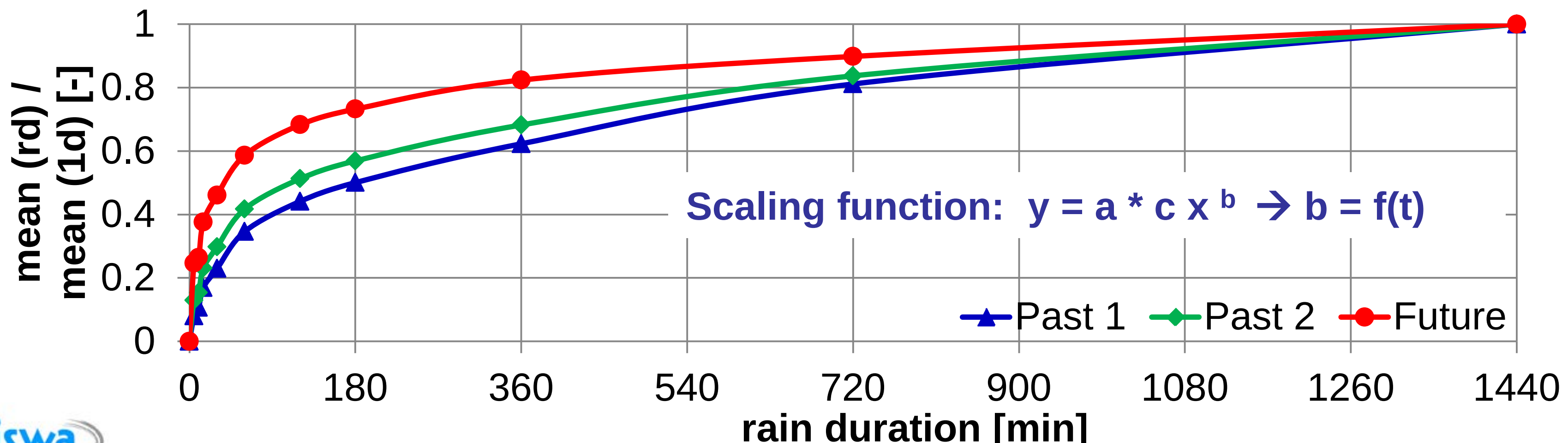
NiedSim Precipitation Generation

- Generation of precipitation time series for any location
  - → random temporal order
- Optimization using simulated annealing
  - (auto-correlation, monthly sum, …)



New Input for NiedSim-Klima

- Temporal sequence of circulation pattern from the GCM (ECAHM5)
  - 1h-probability of precipitation
- From RCM (REMO)
  - max. daily sum of precipitation
- From measurements:
  - Change in scaling properties (mean, variance, skewness)
- Generation and optimization analog to NiedSim
  - Properties unknown are removed (e.g. yearly sum of precipitation)



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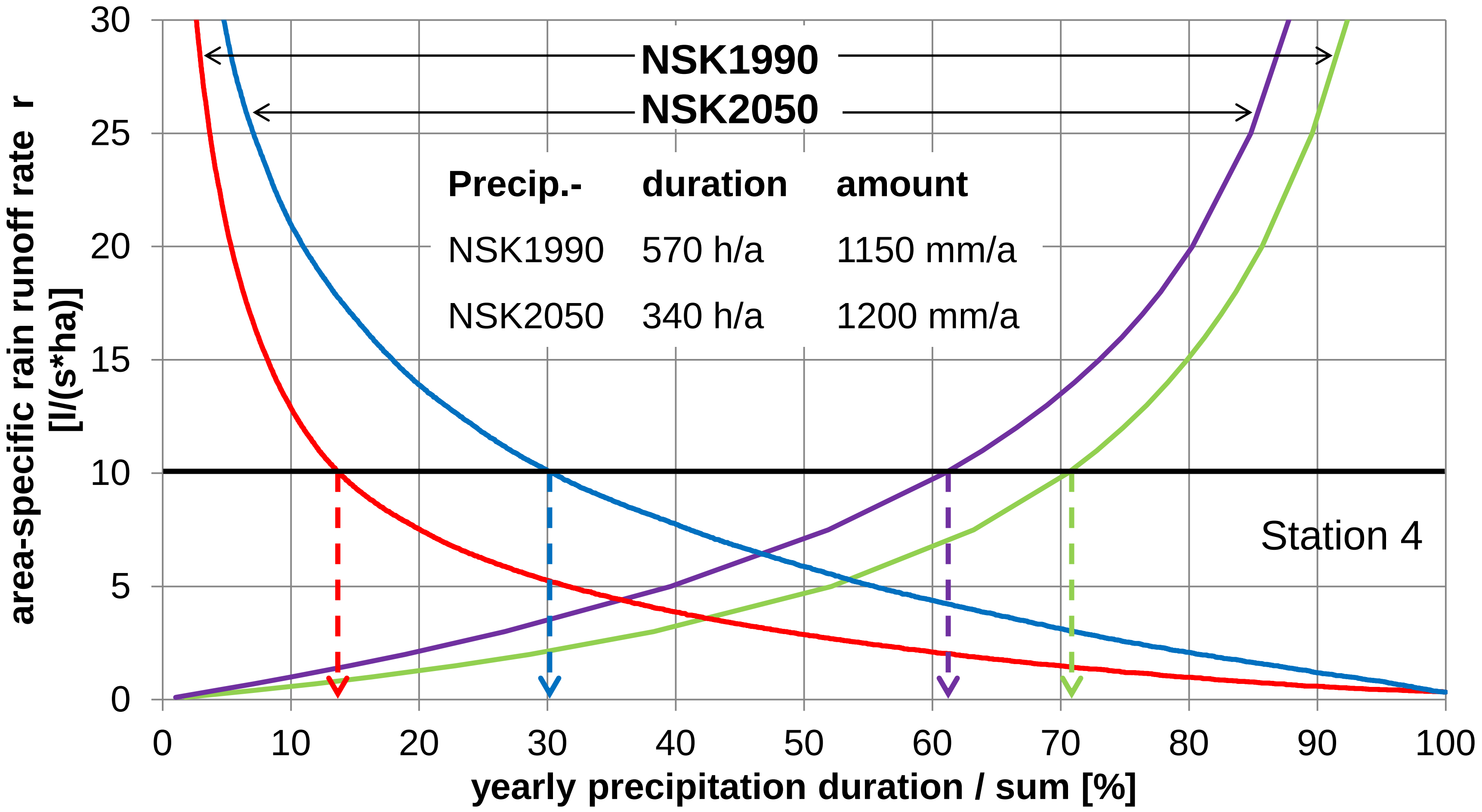
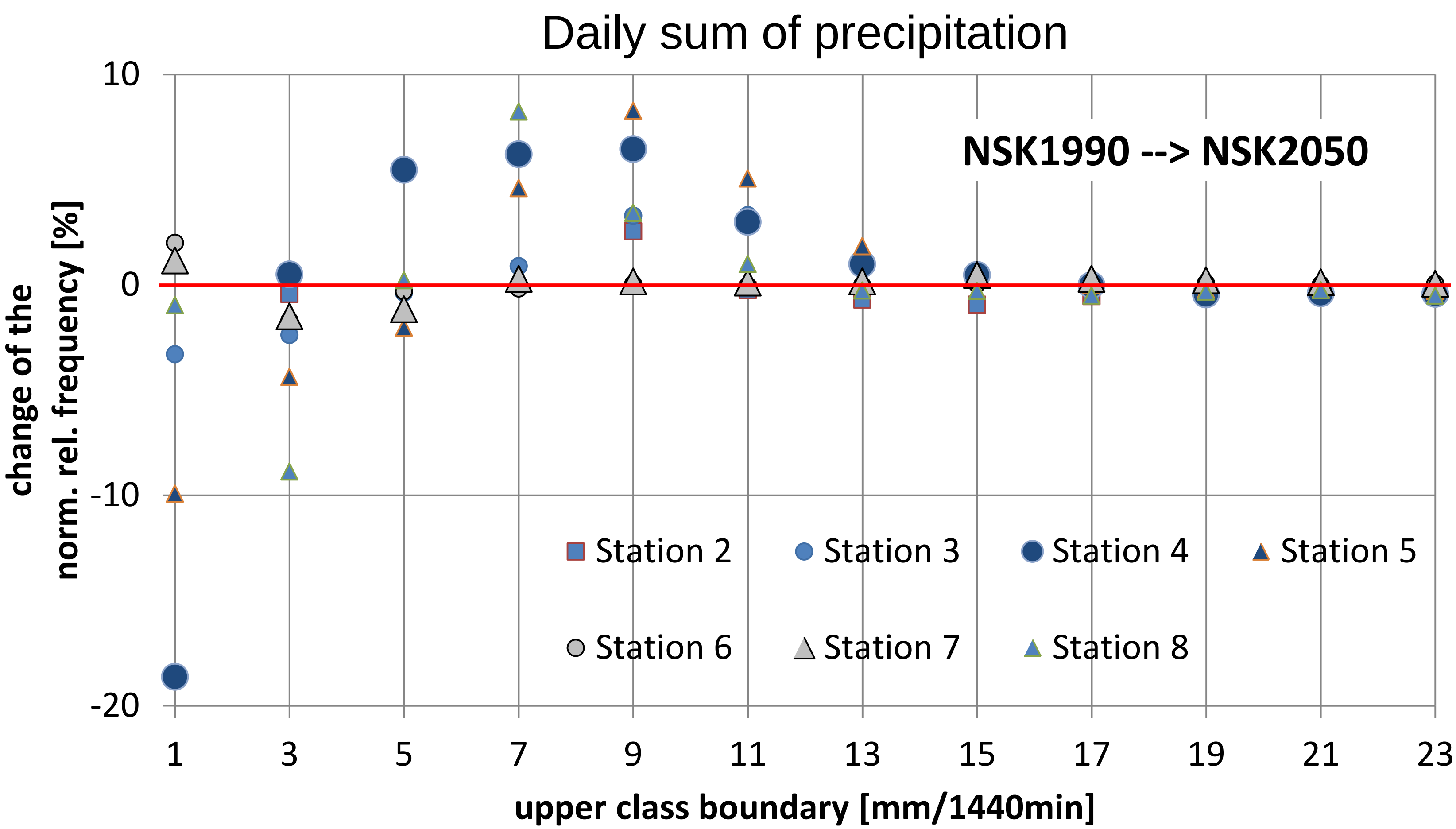
Precipitation



- More dry hours per year
- More intense precipitation
- Increase of overflow from CSO

Similar for other stations

Precipitation

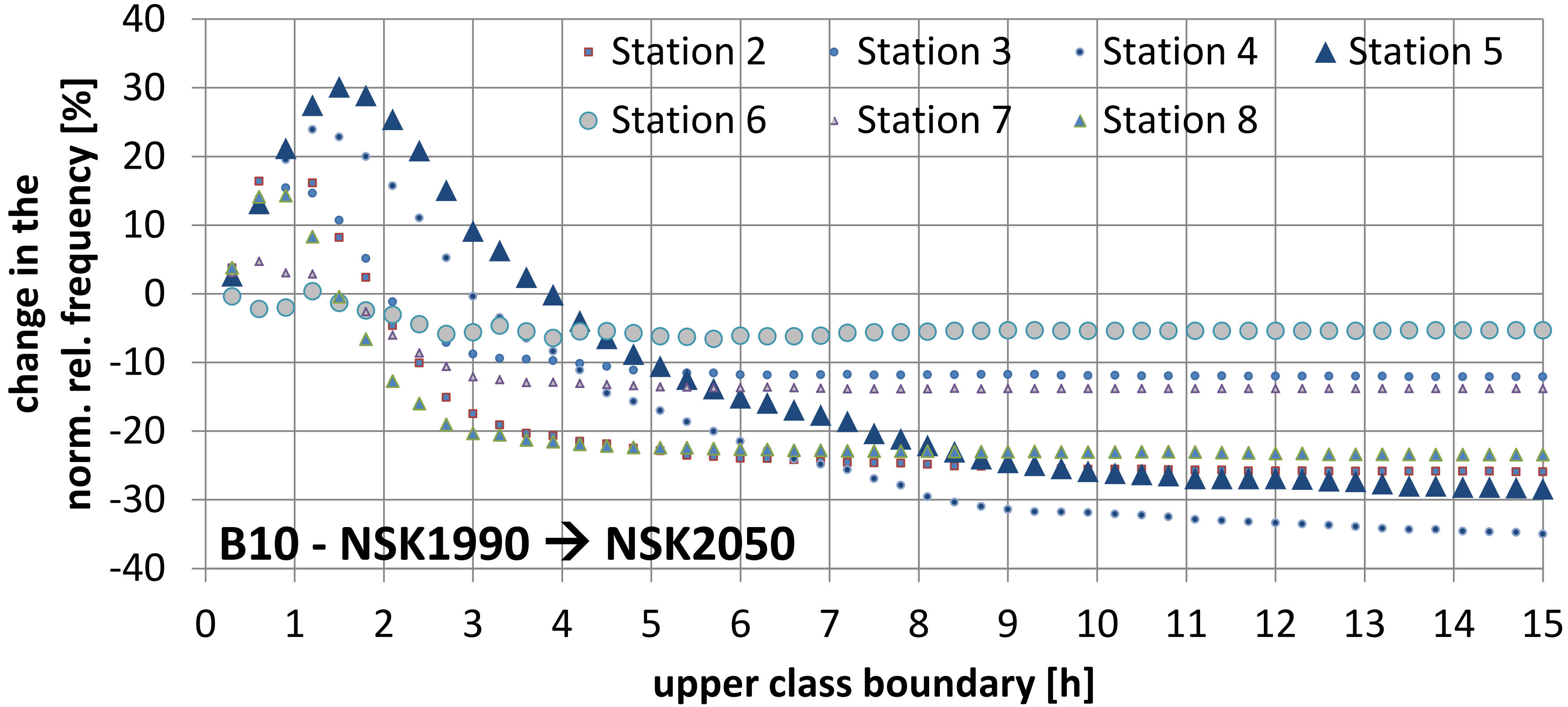


- More events with 5 to 13 mm/d
- Less dry days (< 1 mm/d)

Similar for other rain durations

Overflow Parameters

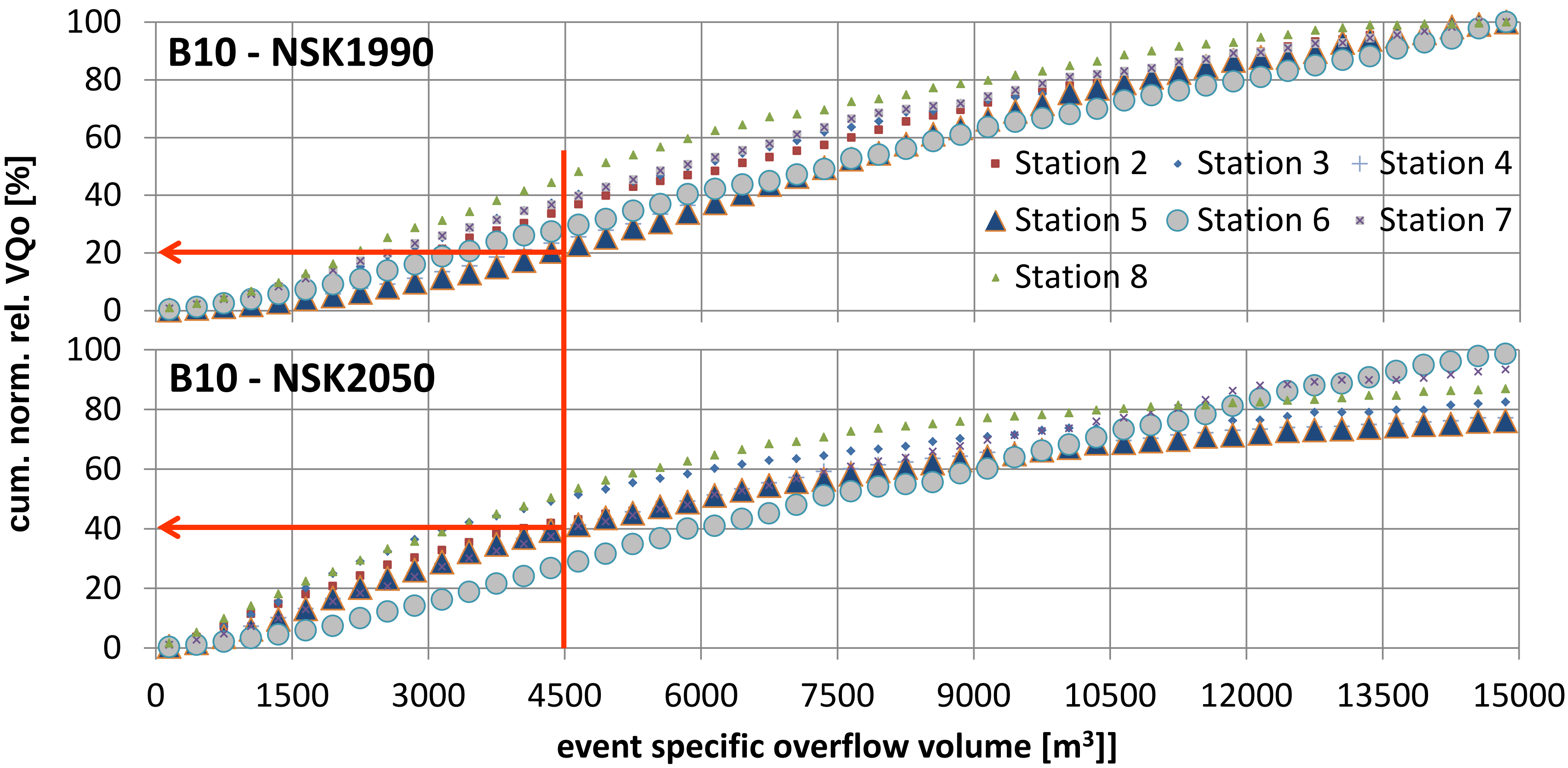
Overflow duration per event (A-128 CSS, CSO storage tank B10)



- Increase in overflow events with a duration of up to 4h
- Decrease of overflow events with a duration of greater 2h

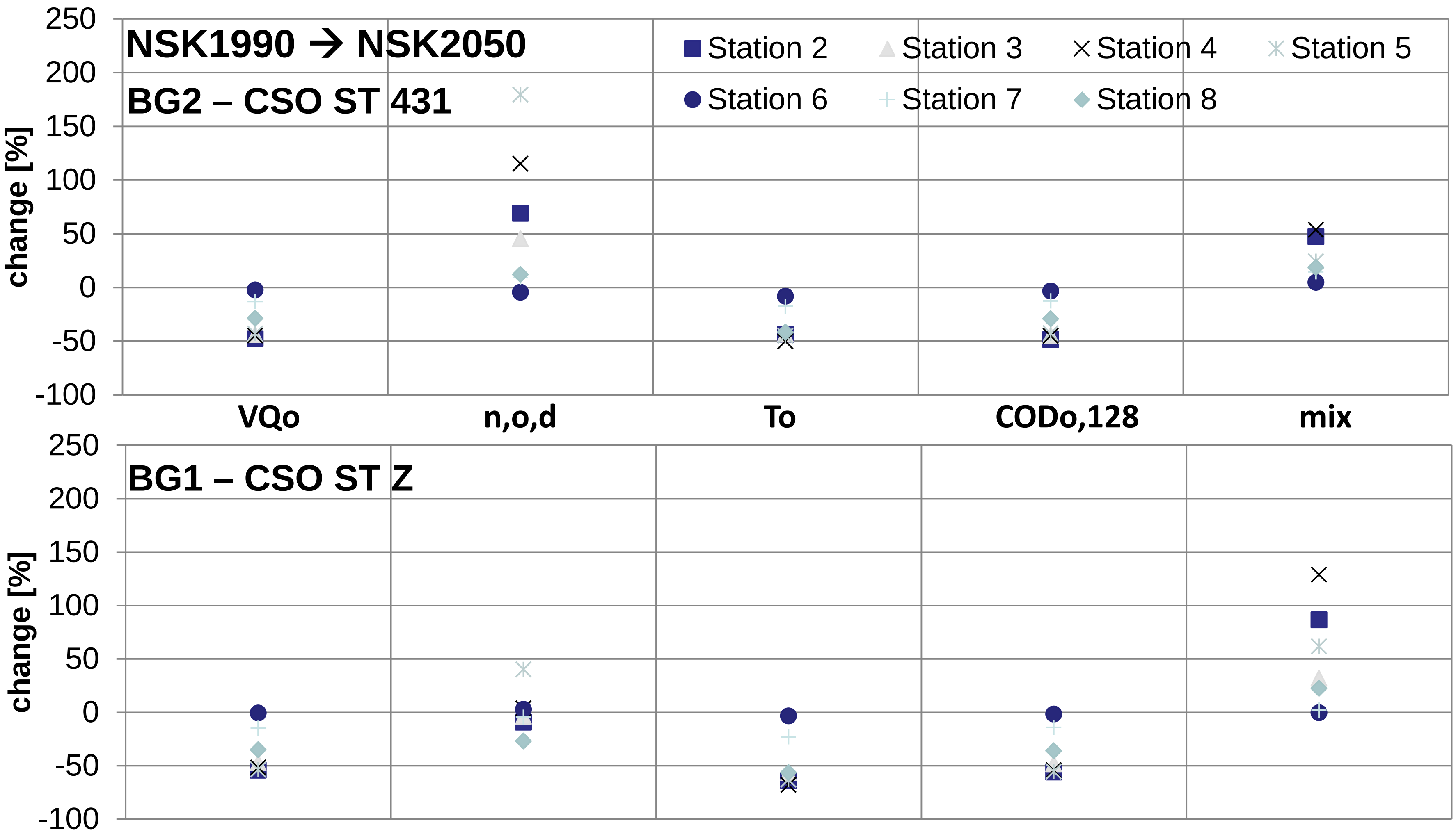
Overflow Parameters

Overflow volume per event (A-128 CSS, CSO storage tank B10)



- A higher percentage of the total overflow volume is generated by “small” events

Overflow Parameters

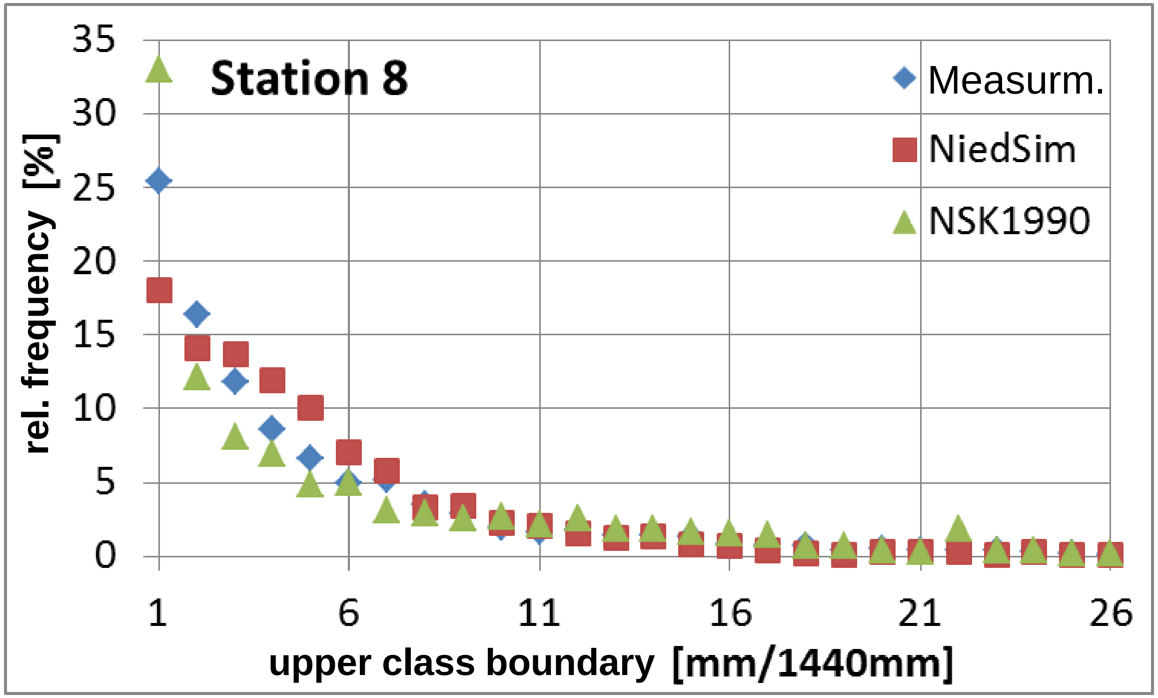


- Up to 70% decrease of VQo, To, CODo for CSO storage tanks
- Up to 200% increase of n,o,d for CSO storage tanks

Measurments vs. NiedSim vs. NiedSim-Klima

Deviations:

- Overestimation of the yearly sum of precipitation
- Differences in the frequency distribution of the precipitation intensity
- Underestimation of extreme events



Reasons:

- Difference in altitude between climate station and generation point
- Missing values and measurement errors

Model Parameters

- Variation of different model parameters by ±20 % (A-128 CSS)
  - flow control rate, CSO storage tank volume, final runoff coefficient, initial runoff coefficient, initial losses, impervious area, water use, infiltration Water, …

		VQo	To	CODo	n,o,d
		[%]	[%]	[%]	[%]
CSO ST	Climate change	-26	-35	-17	+100
	Imperious area / final runoff coefficint	±30	±22	±12	±15
	Flow control rate	±6	±15	±8	±13
CSO	Climate change	+27	+9	+29	+100
	Imperious area / final runoff coefficint	±38	±25	±19	±15
	Flow control rate	±19	±23	±18	±14

Summary

Reliability of precipitation data

- Differences in the frequency distribution, yearly sum
- Sensitive towards the scaling properties

    → Suitable for "relative comparison"

Expected climate change impacts on the precipitation

- Moderate increase in the yearly sum
- Strong regional differences
- Daily precipitation falls in a shorter time period

    → Increase of events that cause overflow for CSO

Summary

Impacts on the overflow patterns

- No serious worsening of the current situation
- Trend towards more frequent but shorter and smaller overflow events
- Decrease of overflow volume and load for CSO storage tanks
- Increase of overflow volume and load for CSOs

Evaluation of possible changes

- No need for a general fundamental redesign
- Increased overflow activity may be critical in some cases
- Increase of manageable overflow (soil retention filters, …)
- Uncertainties in the planning outweigh expected climate change impacts

Thank you

for your attention!

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Stuttgart**