IMPACT

Evaluation of SWAT in the context of climate change in a German lowland catchment

Björn Guse, Matthias Pfannerstill and Nicola Fohrer

CAU

Abteilung Hydrologie und Wasserwirtschaft

iwrm-net

Bundesministerium für Bildung und Forschung

Motivation

- Changing climate conditions affect hydrological cycle
- Demand for modeling of future development of the hydrological cycle
- Modeling by using a calibrated hydrological model for recent conditions and simulating of different climate change scenarios
- Comparison of recent and future model results
- Investigation whether the hydrological model is able to reproduce the hydrological cycle for recent and for changed climate conditions

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Methodical approach

1. Is SWAT able to model the discharge for all months?

2. Which are the months with the largest climate change effect?

Calibration and evaluation of SWAT for recent period

Climate change scenario runs for future period

Determination of months with model short-comings

Detection of the months with the largest climate signal on discharge

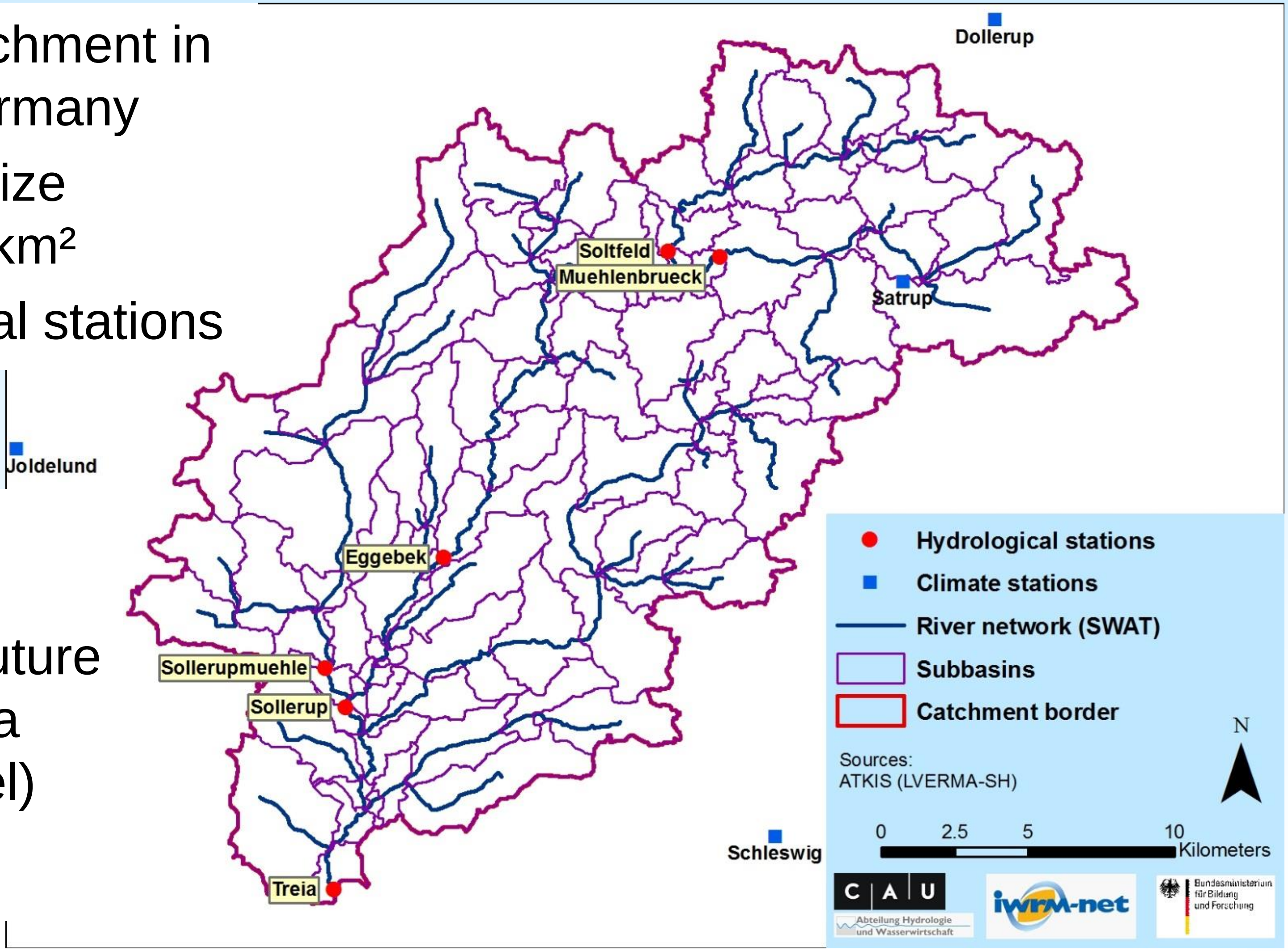
Linkage of limitations in the recent period to months with largest changes in the future period

Requirement for a better adaption of SWAT to changing conditions?

Treene catchment – SWAT subbasins

- Lowland catchment in Northern Germany
- Catchment size (Treia): 481 km²
- 6 hydrological stations

- 4 climate stations with recent and future scenario data (STAR-model)



STAR data set provided from Potsdam Institute for Climate Impact Research (Orlowsky et al., 2008)

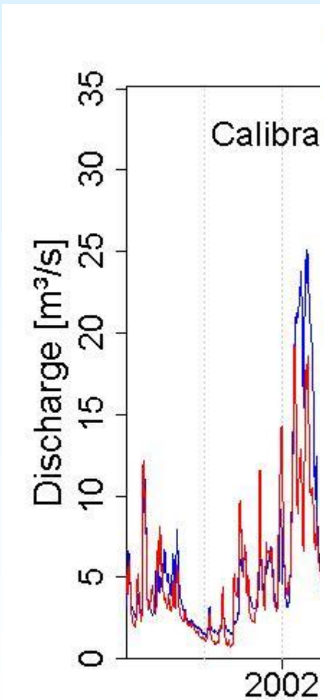
SWAT model calibration

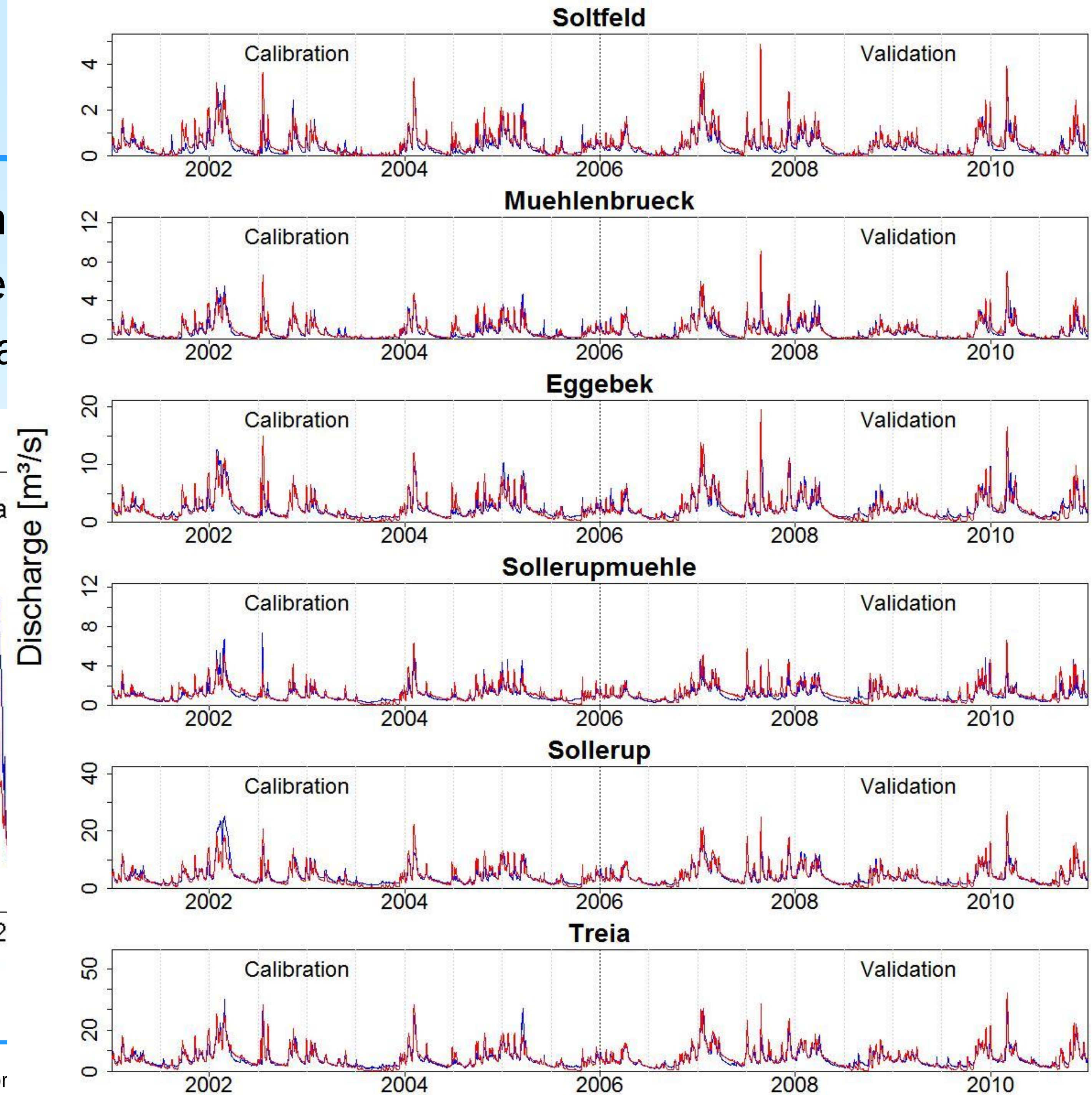
- Selection of a constant parameter set for all stations
- Spatial variation of the most sensitive parameters for the six hydrological stations

Parameter	All sites
SURLAG	0.4
CANMX	+1.55
CN2	+1.31
SOL_AWC	+0.1
SOL_K	x 5.86

Parameter	Soltfeld	Muehlen-brueck	Eggebek	Sollerup-muehle	Sollerup	Treia
GW_DELAY	3	3	8	8	10	10
ALPHA_BF	0.025	0.03	0.014	0.01	0.01	0.01
RCHRG_DP	0.35	0.3	0.02	0.1	0.02	0.05
ESCO	0.5	0.5	0.9	0.9	0.9	0.9

- Comparison
- Visual inspe
- Underestima





Discharge data is pr

Performance measures for calibration and validation period

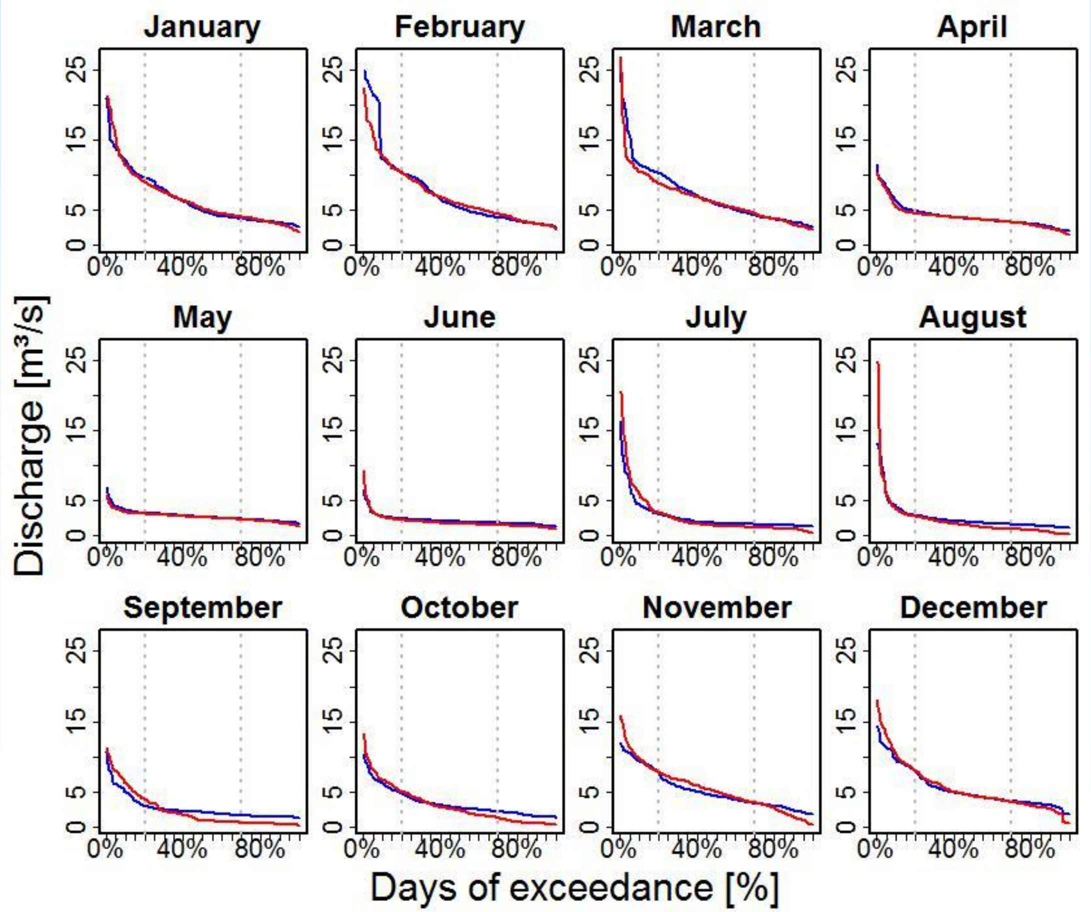
- Good results of four performance measures for the six hydrological stations (daily calculation)

Hydrological station	Calibration 2001-2005				Validation 2006-2010			
	CE	PBIAS	MRE	RSR	CE	PBIAS	MRE	RSR
Soltfeld	0.73	25.2	0.33	0.52	0.71	22.2	0.18	0.54
Muehlenbrueck	0.82	12.6	0.39	0.43	0.84	10.1	0.13	0.41
Eggebek	0.72	4.3	-0.03	0.53	0.78	-0.8	-0.07	0.46
Sollerupmuehle	0.65	8.5	0.06	0.59	0.42	21.1	0.23	0.76
Sollerup	0.72	-8.2	-0.12	0.53	0.76	1.7	-0.03	0.49
Treia	0.77	3.2	-0.02	0.46	0.81	2.8	-0.01	0.44

CE=Nash-Sutcliffe Efficiency, PBIAS=Percentual Bias, MRE=Mean relativ error, RSR=RMSE standard deviation error

Long-term averaged monthly Flow Duration Curve (FDC) for Sollerup

- Ranking of discharge magnitudes
- Estimation how often a certain discharge is exceeded
- Monthly FDCs illustrates seasonal variations in discharge
- Overall good fit of measured and modeled discharge
- Underestimation of low flows in autumn



Climate change scenario

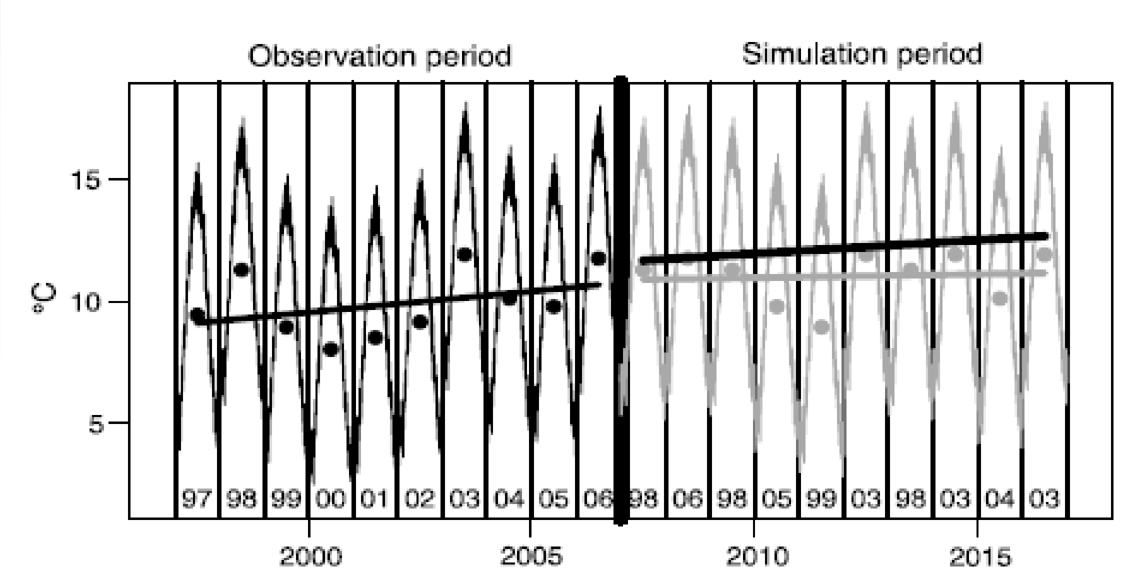
1. Selection of two climate scenarios from the STatistical Regional model (STAR) (Orlowsky et al., 2008) with linear temperature increases of 0K and 3K until 2060
2. SWAT model runs with climate input data from the two STAR scenarios
3. Determination of the signal of climate change on discharge in a monthly resolution for the future period (2021-2060)

STAR model

STAtistical Regional model (STAR)

- Resampling approach
- Based on statistical characteristic of current climate
- Linear regression line of future climate
- Assuming that simulated climate is comparable with current one

- Temporal and spatial consistency among variables
- 100 simulations for each scenario

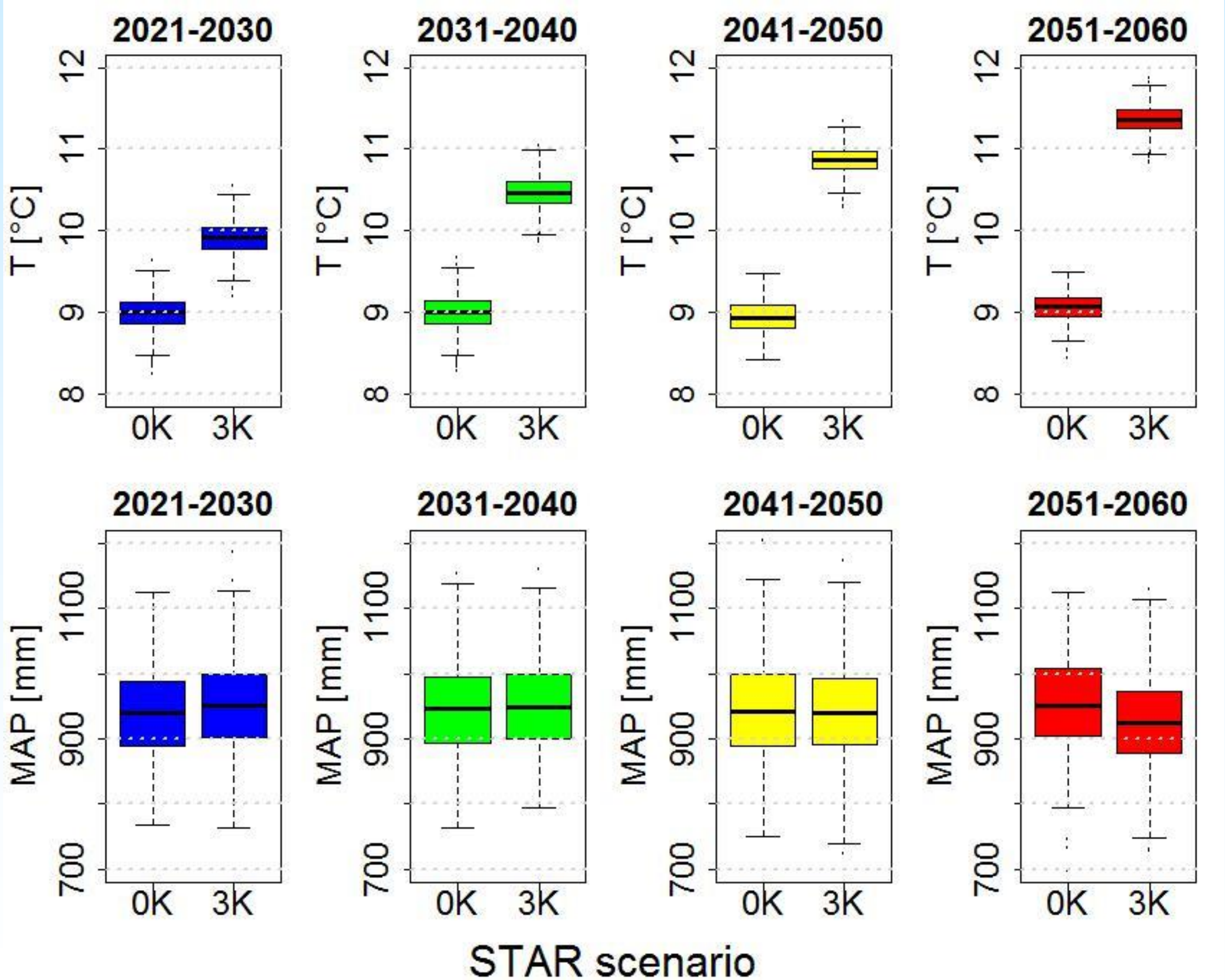


From Orlowsky et al., 2008

Werner et al., 1997; Orlowsky et al., 2008

Development of temperature and precipitation

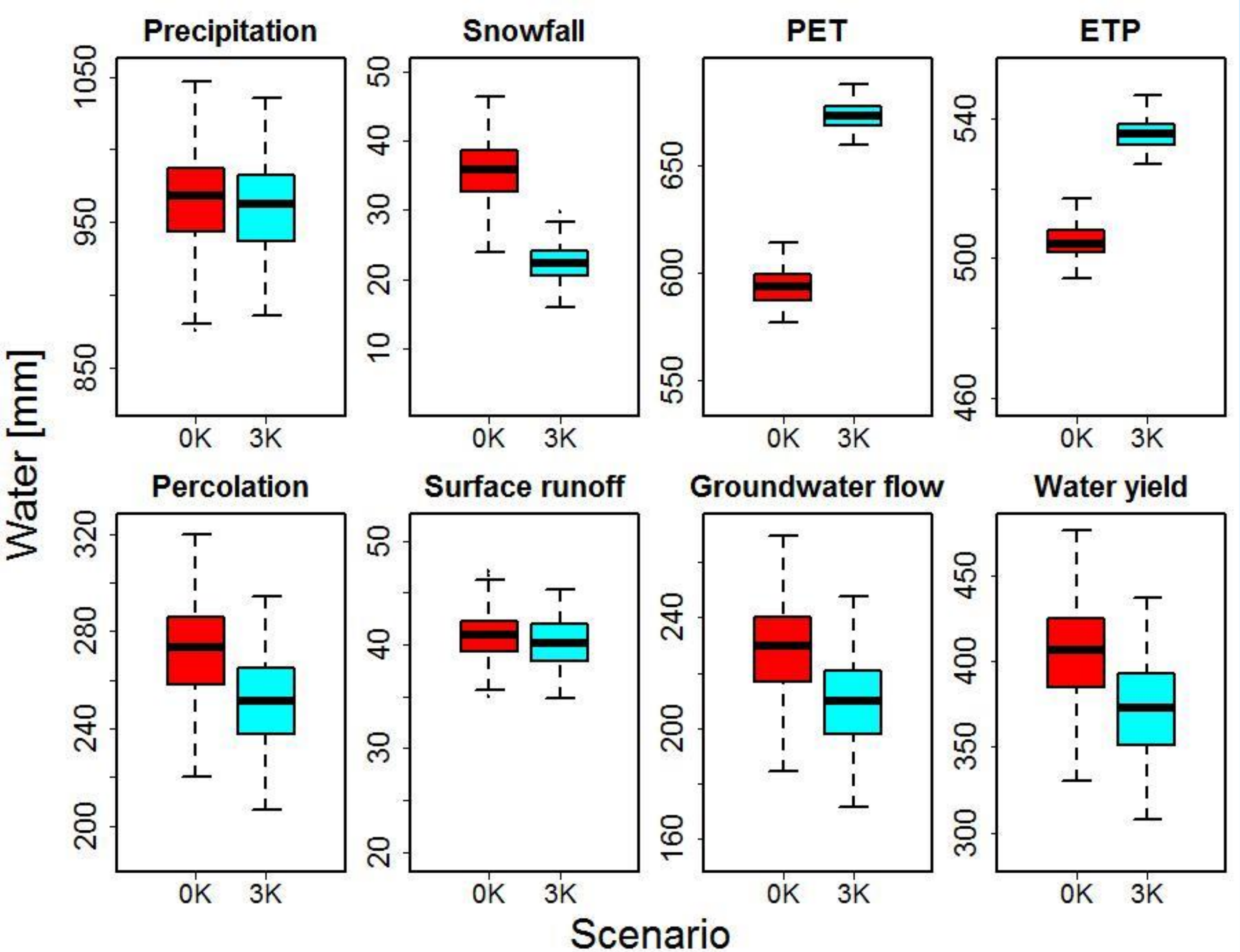
- Temperature difference increases by the end of the simulation period
- In the last period slight change in precipitation



STAR data set (Orlowsky et al., 2008) provided by the Potsdam Institute for Climate Impact Research (PIK)

Water balance components (2021-2060)

- Small changes in precipitation and surface runoff
- Decrease of snowfall and groundwater flow
- Increase of ETP and PET



- Results derived from the output.std

Monthly water components

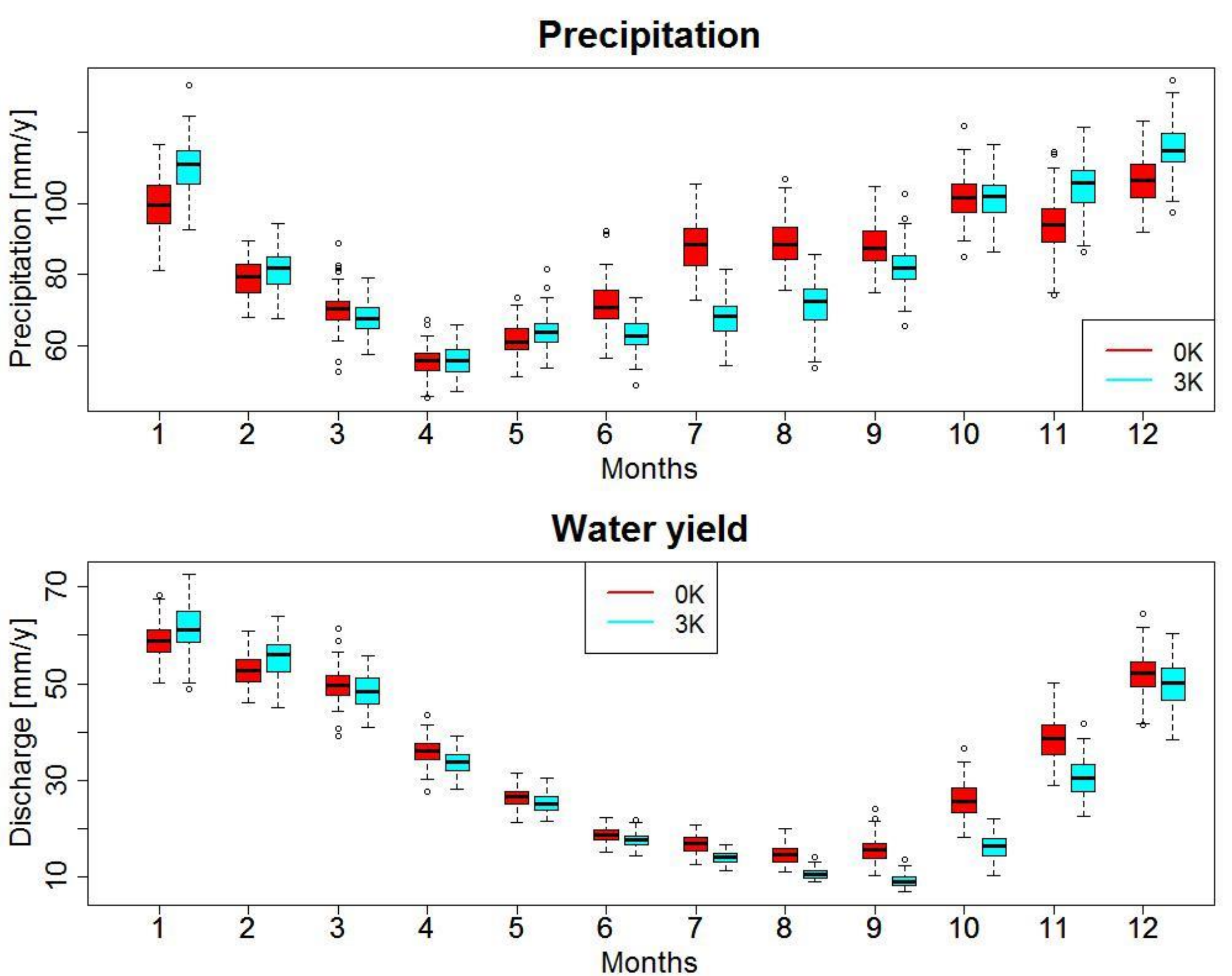
Precipitation:

- Decrease in summer, increase in winter

Water yield:

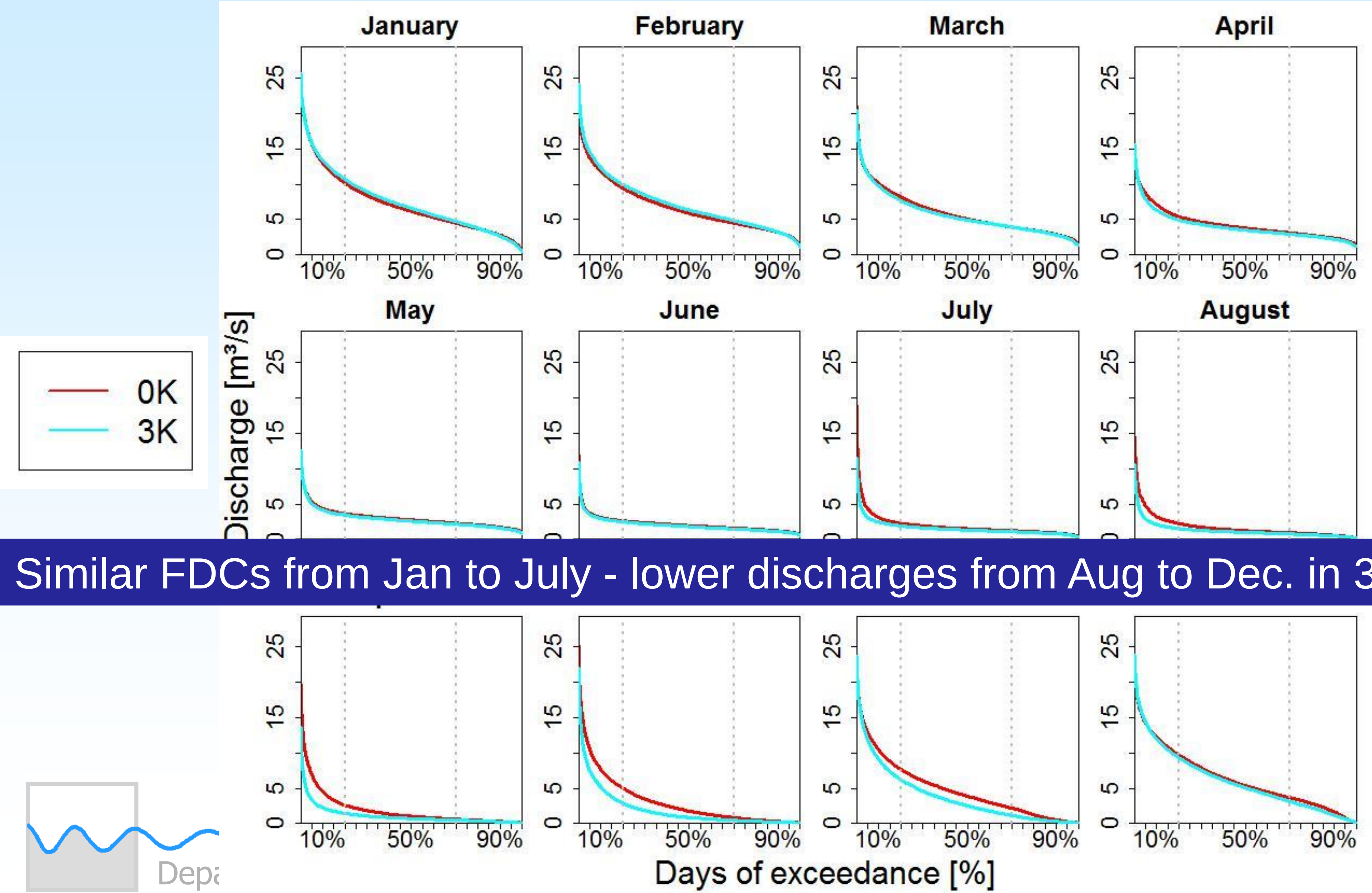
- Decrease of water yield in late summer

- Time lag in discharge due to the storage



- Results derived from the output.std

Comparison of FDCs for 0K- and 3K scenario



Similar FDCs from Jan to July - lower discharges from Aug to Dec. in 3K

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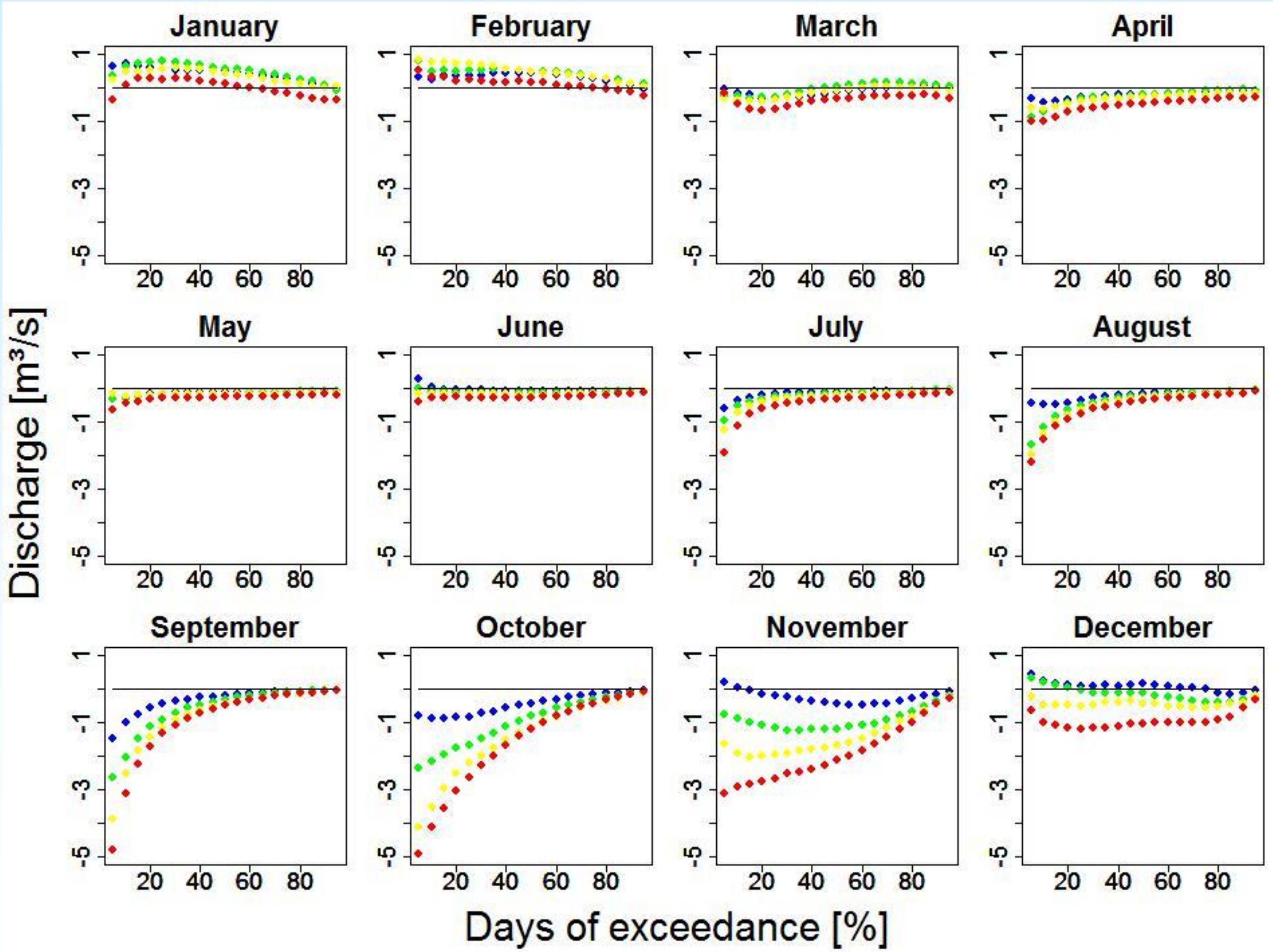
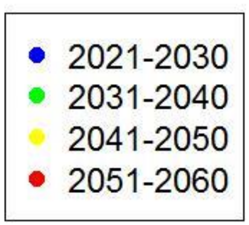
Differences between 0K and 3K-scenarios

- Similar values for 0K in the four sub-periods
- Discharge decreases in 3K-scenario
- Largest effect for 2051-2060 in autumn months

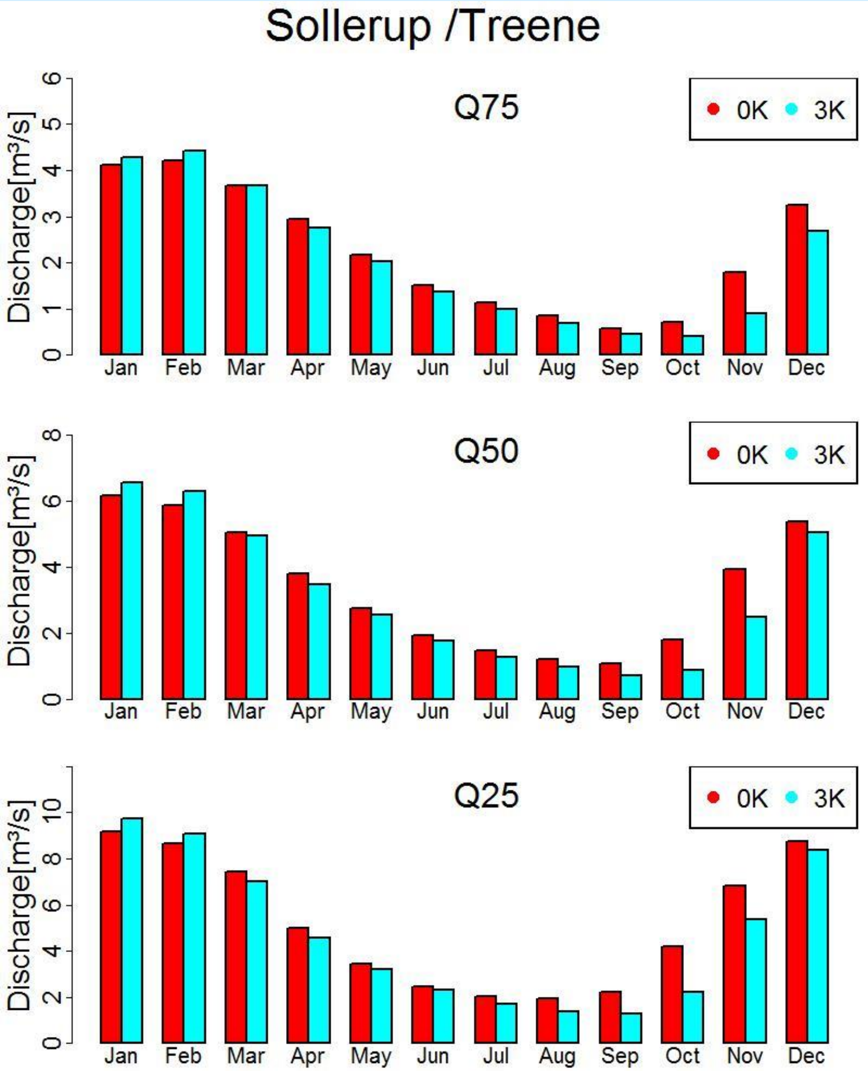




Monthly comparison of climate change scenarios for three discharge quantiles

- Comparison of discharge quantiles for
  low discharge (Q75)
  medium discharge (Q50)
  high discharge (Q25)

- Differences between 0K and 3K are similar for the three discharge quantiles



Conclusion

- SWAT model is able to reproduce the hydrological conditions of the Treene catchment
- Short-comings of model evaluation for recent period in autumn months
- Seasonal variations of climate change effects are projected with the largest changes in autumn
- Coincidence with periods of the largest effect of climate change on discharge for future period
- Requirements for improvements in modeling of low flows to obtain a better adaption of SWAT for climate change applications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Thank you
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