POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Projections of future flood and drought conditions in Germany by combining RCMs and a regional hydrological model

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Regional impacts and strategies
Research Domain II - Climate Impacts & Vulnerabilities
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Leibniz Gemeinschaft

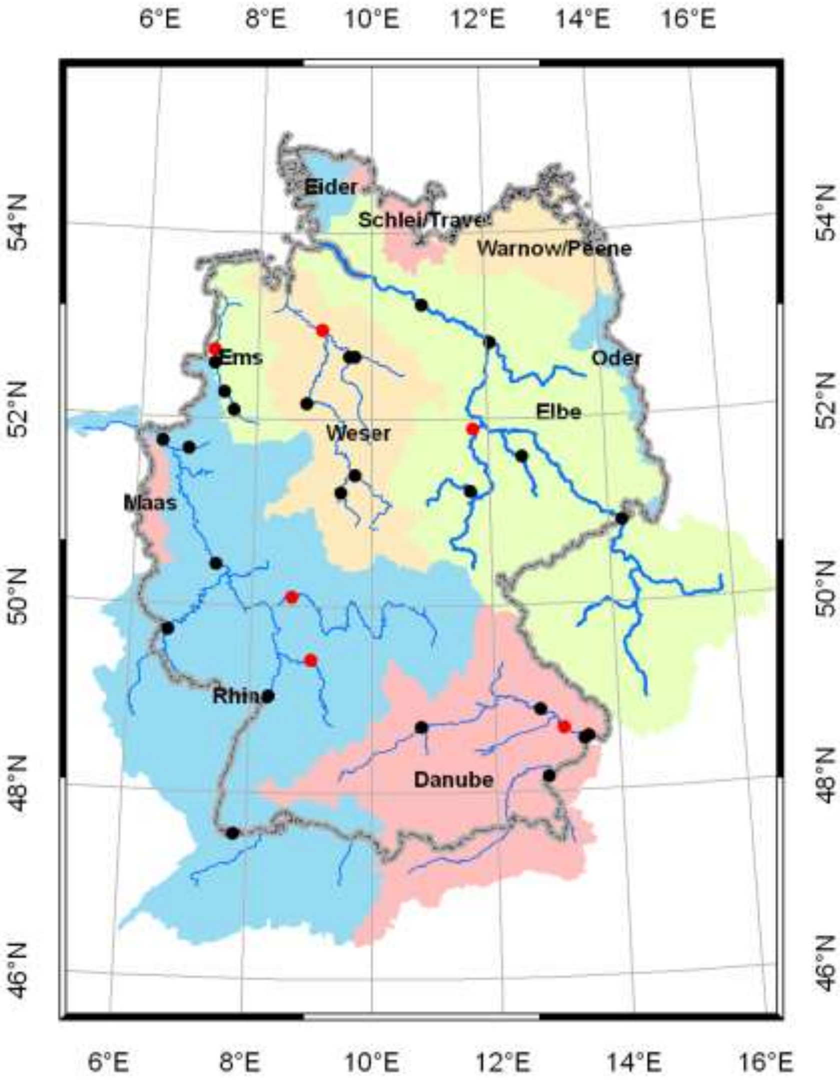

Drought 2003
in the future?
Dry river bed in Dresden in 2007
(Source: Reuters)
Neisse river flood on August 8, 2010.
AFP PHOTO / ROBERT MICHAEL

Introduction – Water problems in Germany

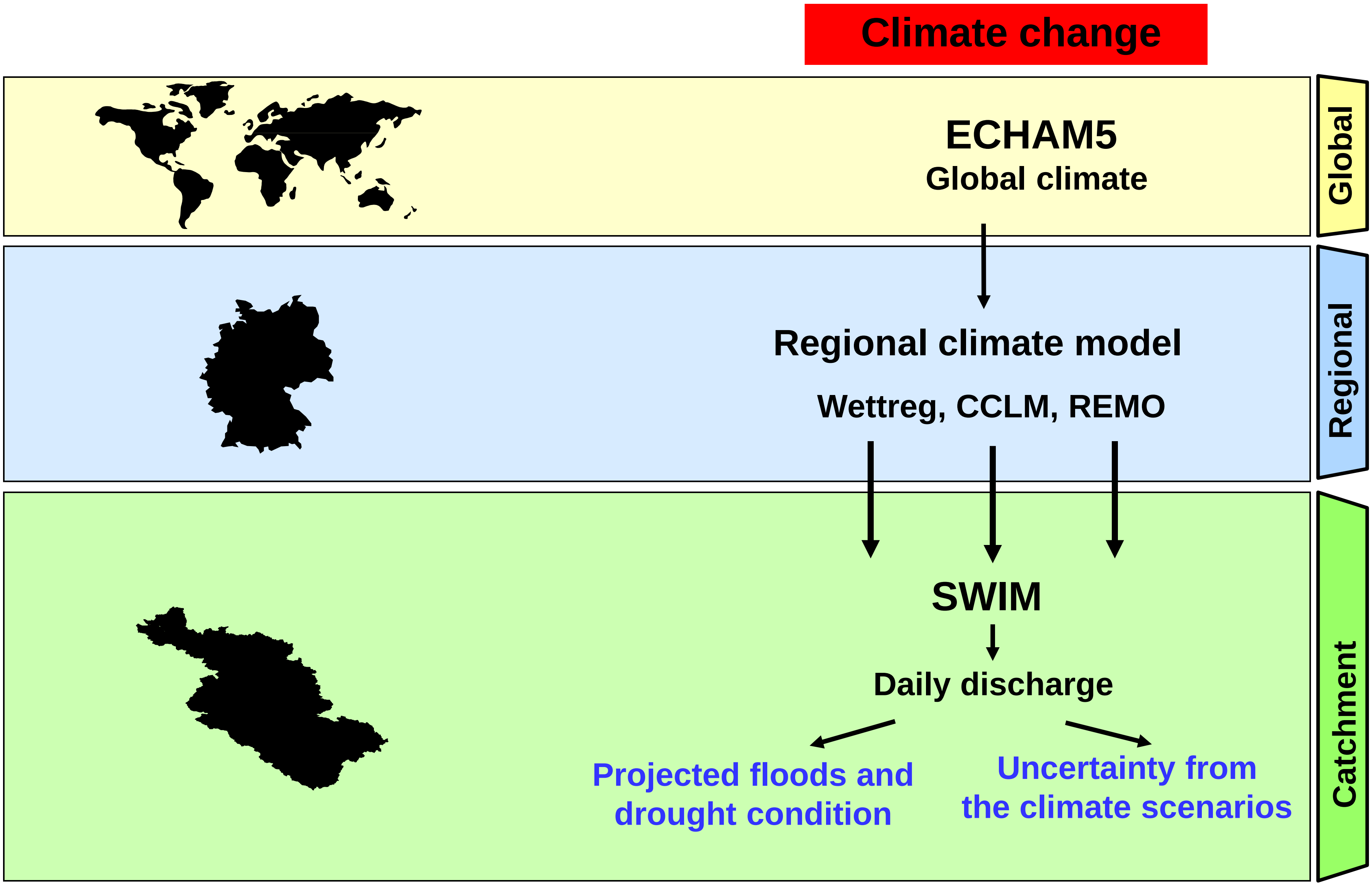
- **More often and more intensive floods and pronounced droughts under climate change**

- **Uncertainty of the climate projections and hence of the impacts on both**

Introduction - Study area



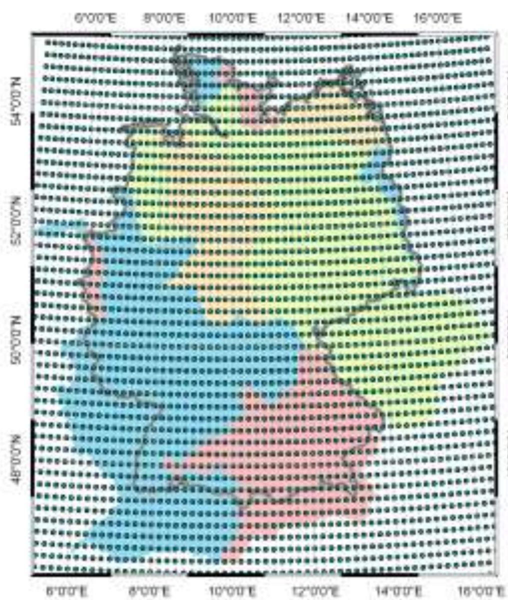
Introduction - Model system



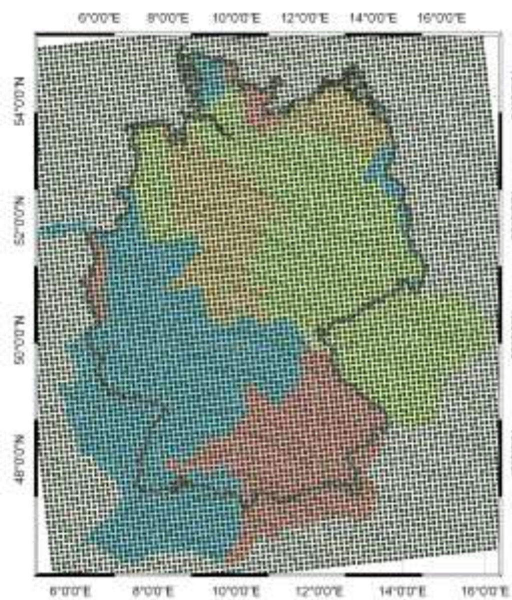
Method - Regional Climate models (RCMs)

RCMs	Model type	Simulation period	GCM based	Emission scenario	Realization per scenario	Spatial resolution
CCLM	Dynamic	1960-2100	ECHAM5	A1B, B1	2	0.2°
REMO	Dynamic	1951-2100	ECHAM5	A1B, A2, B1	1	0.088°
Wettreg	Statistical-empirical	1961-2100	ECHAM5	A1B, A2, B1	20	1965 stations in Germany

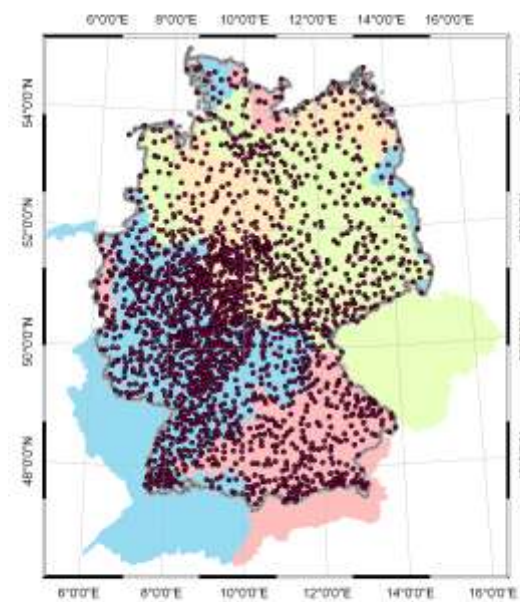
CCLM



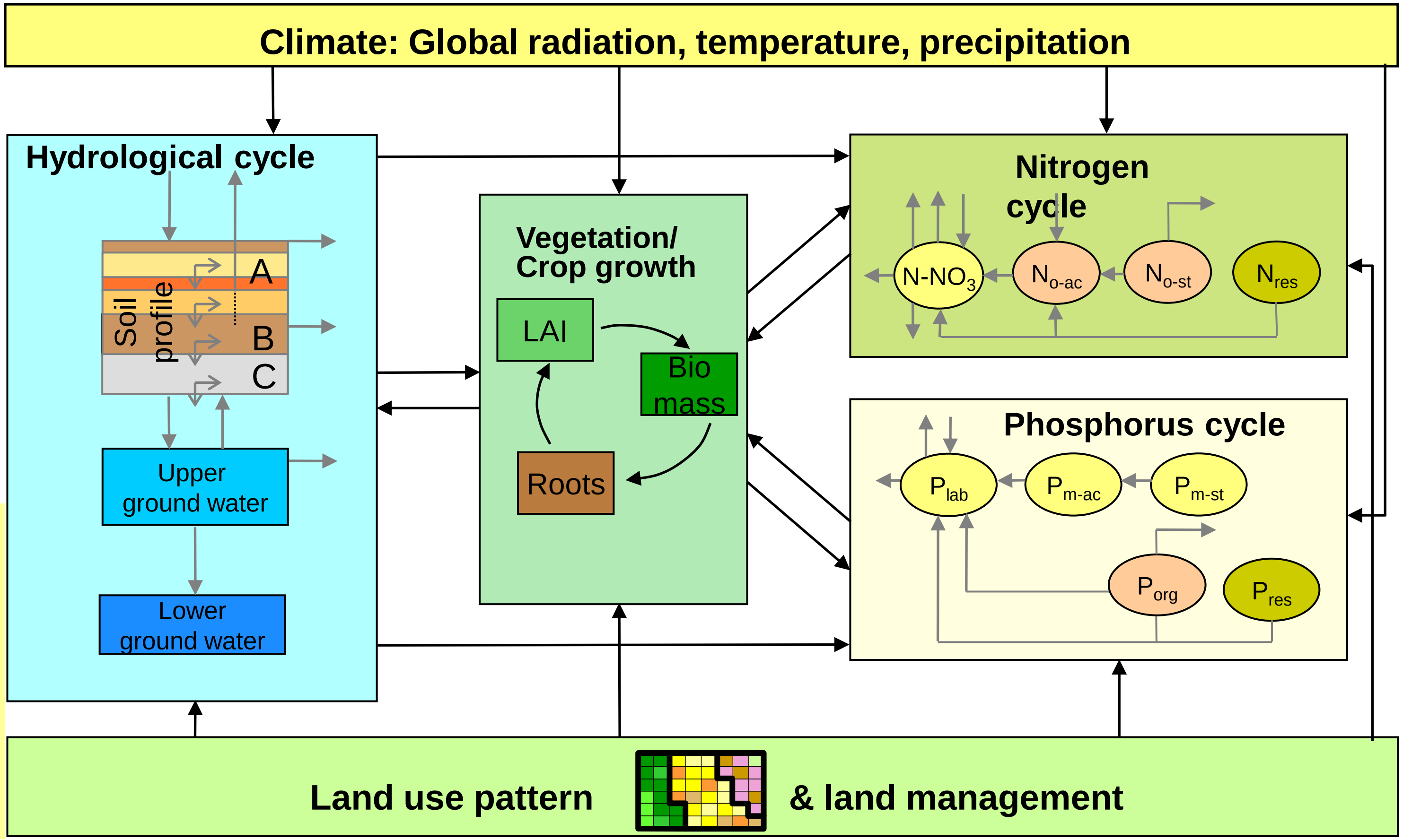
REMO



Wettreg



The Model SWIM (Soil and Water Integrated Model)



SWIM *was developed in PIK, Potsdam based on* ***SWAT-93*** *and* ***MATSALU*** *for climate and land use change impact studies*

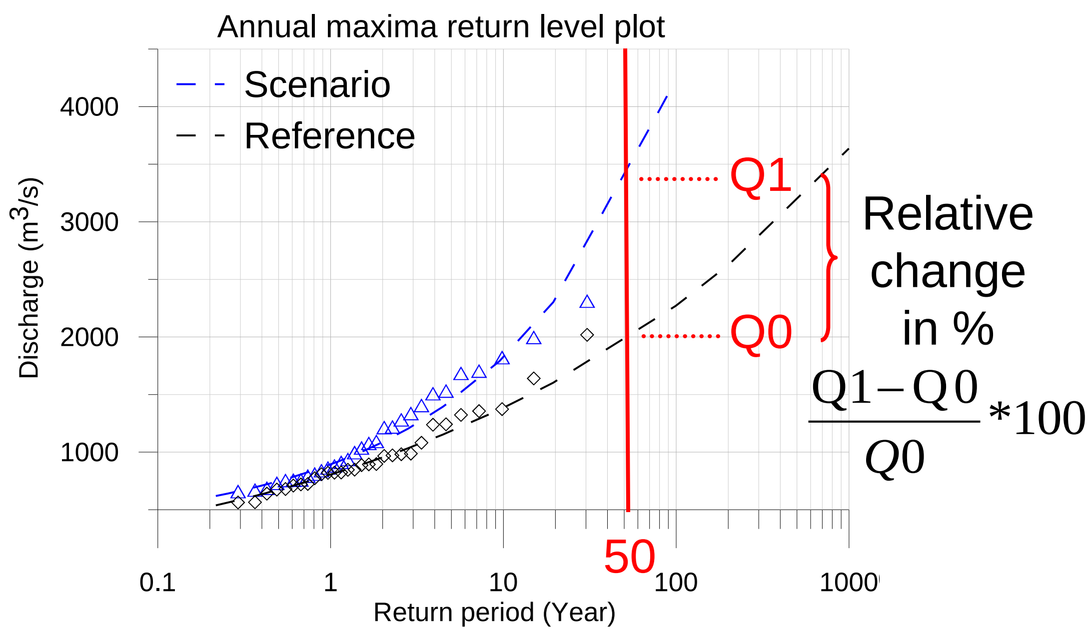
(Krysanova et al., 1998)

Methods - flood and low flow indices

✓ Generalized Extreme Value (GEV) distribution (Coles, 2001) for fitting annual maximum discharges and annual minimum 7-day mean flows:

$$G(z) = \exp\{-[1+\xi(\frac{z-\mu}{\sigma})]^{-\frac{1}{\xi}}\}$$

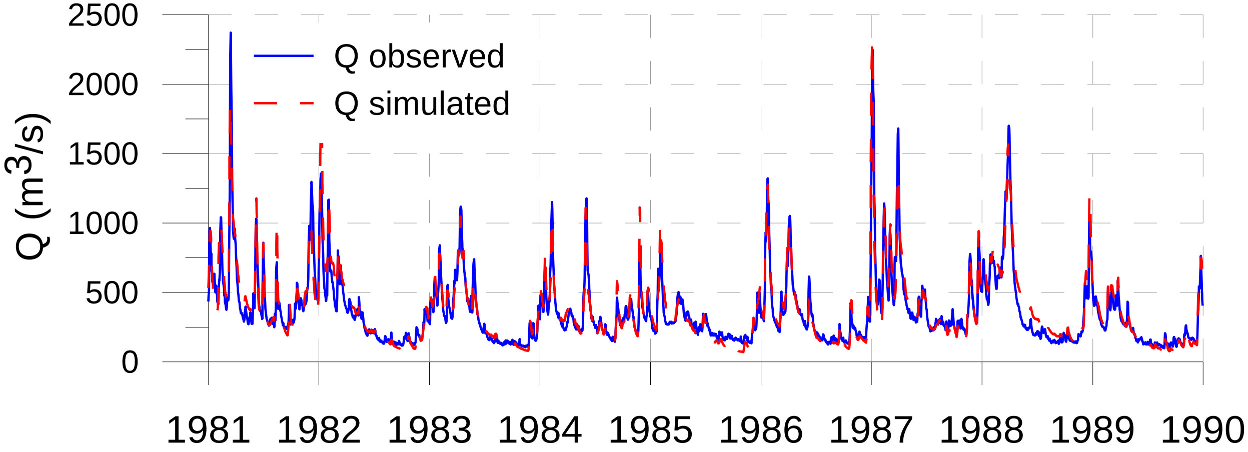
shape parameter ξ, location parameter μ and scale parameter σ (>0)



$$\frac{Q1-Q0}{Q0}*100$$

Calibration results – two examples

(a) Intschede (Weser)

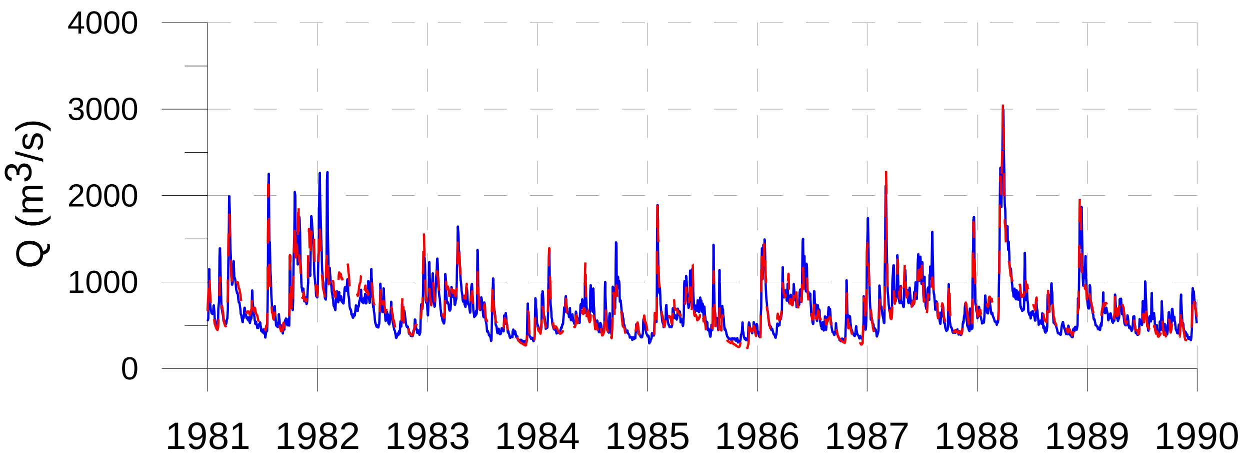


Calibration period

Efficiency: **0.90**

Deviation: 1%

(b) Hofkirchen (Danube)



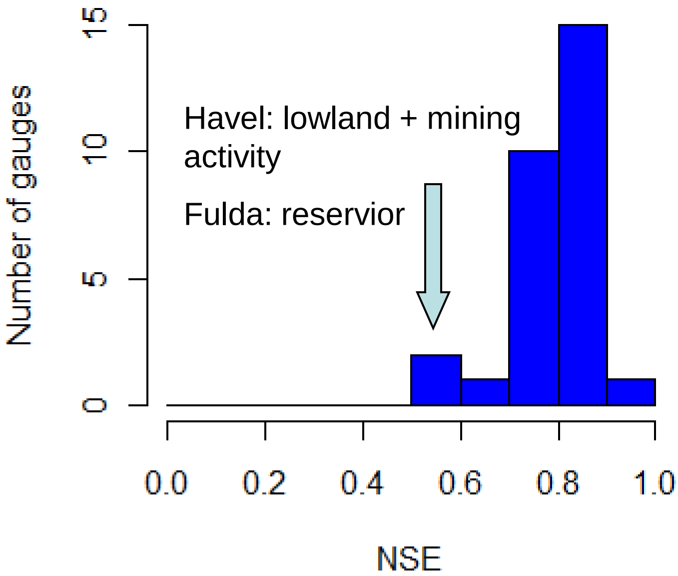
Calibration period

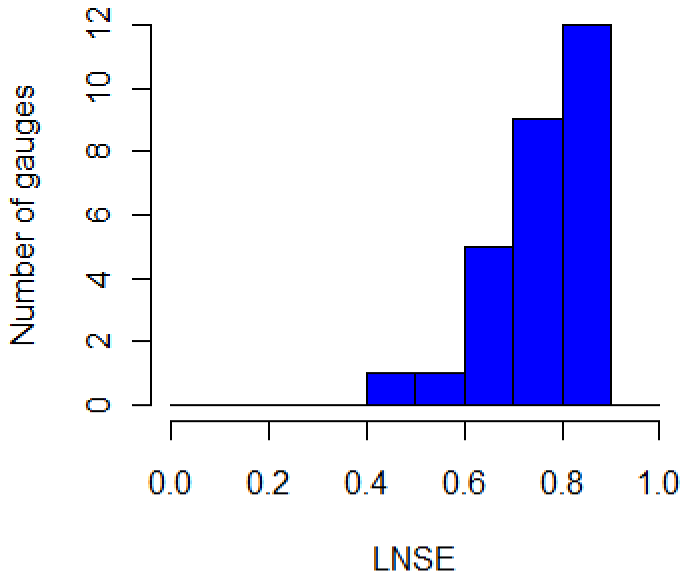
Efficiency: **0.87**

Deviation: **0%**

Results - calibration and validation

Distribution of the statistical results obtained from all 29 gauges in the control period (1961 - 2000)

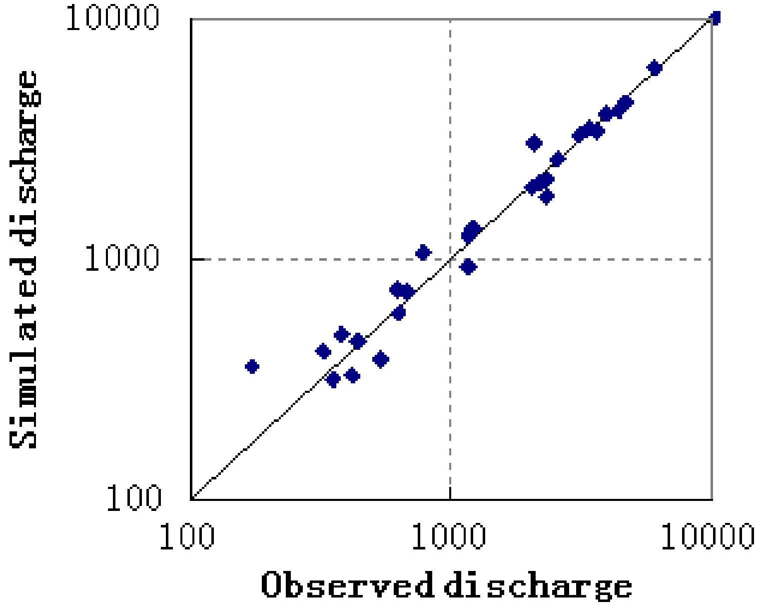




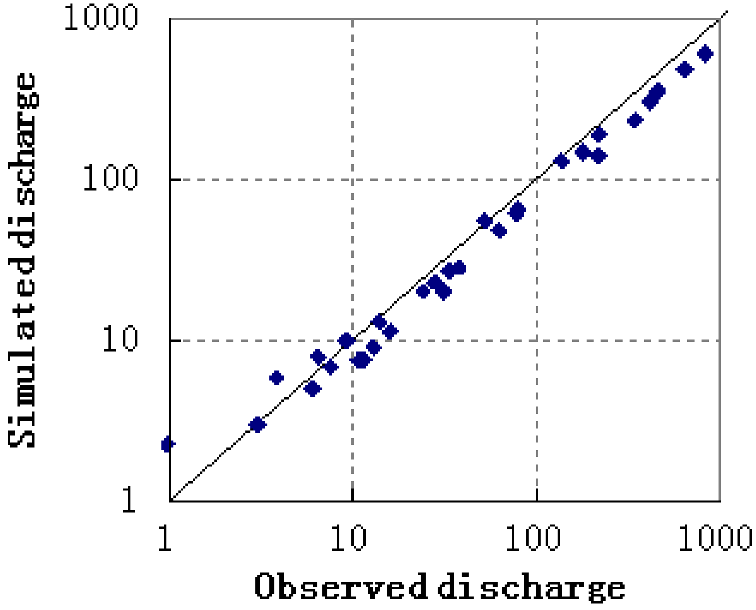
Huang S, Krysanova V, Österle H, Hattermann FF (2010) Simulation of spatiotemporal dynamics of water fluxes in Germany under climate change. Hydrol Process. doi: 10.1002/hyp.7753

Result – calibration and validation

50-year flood level



50-year low flow level

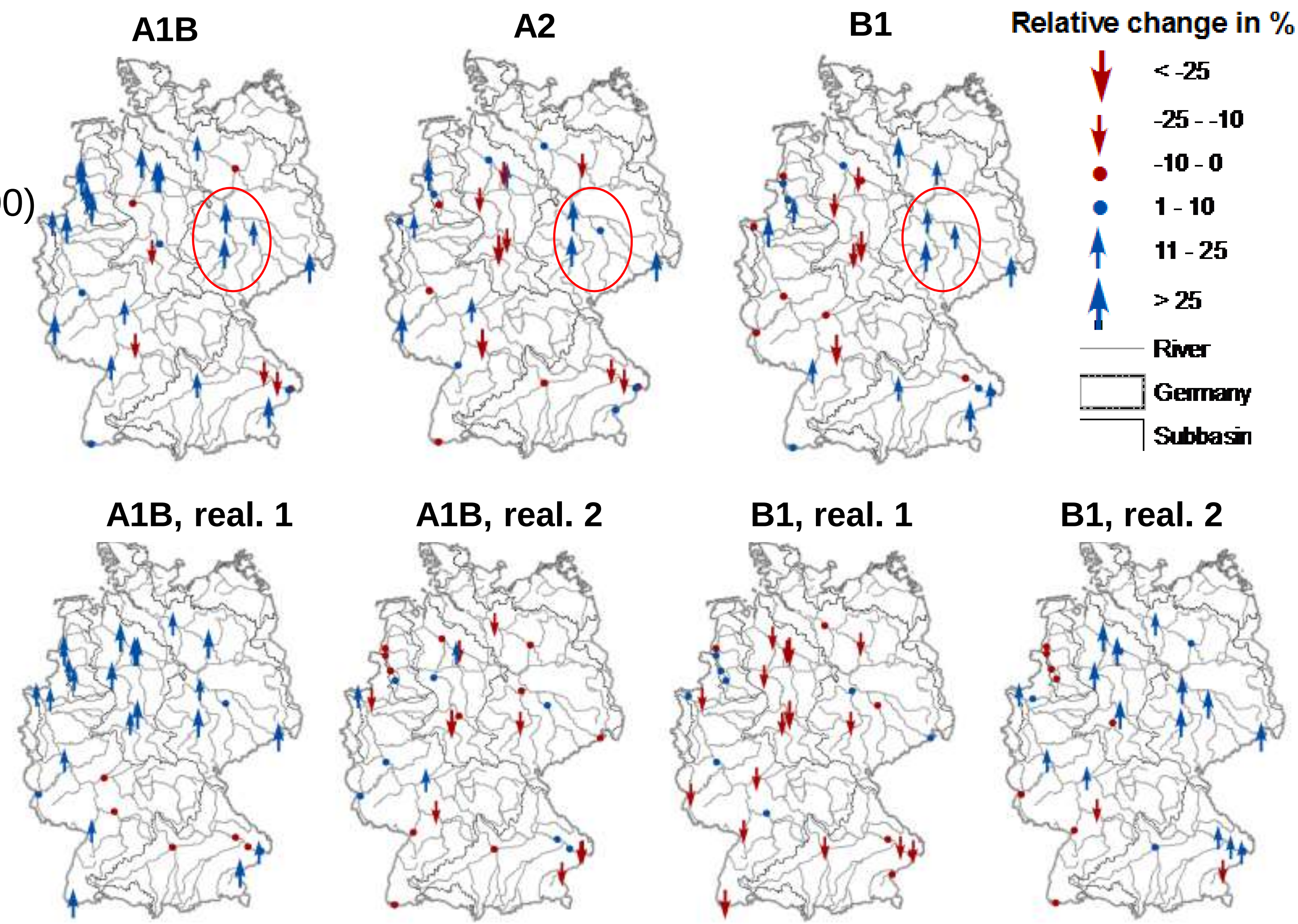


Results – changes in 50-year flood level

(2061 – 2100)
vs
(1961 – 2000)

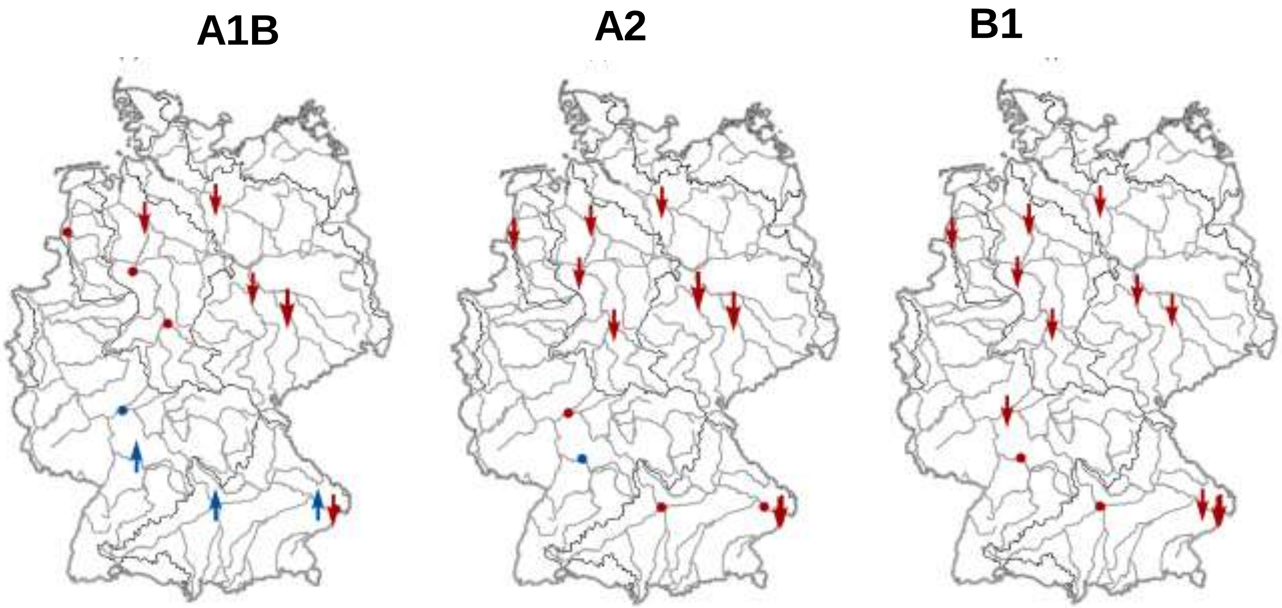
REMO

CCLM



Results – changes in 50-year flood level

Wettreg



Large uncertainty in flood projection due to:

- RCM structures
- Different emission scenarios
- Different realizations by CCLM.

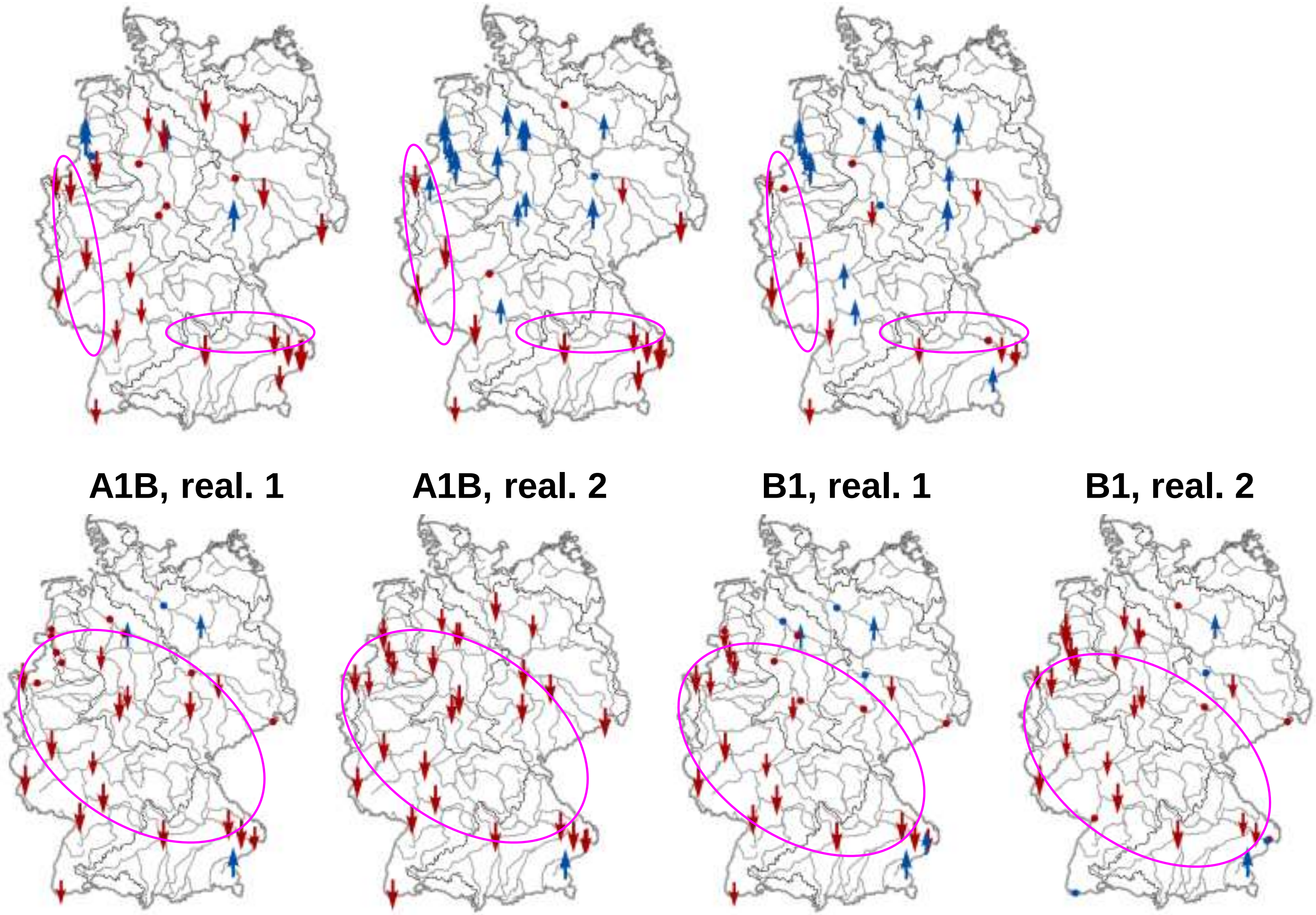
Results - changes in 50-year low flow level

A1B A2 B1

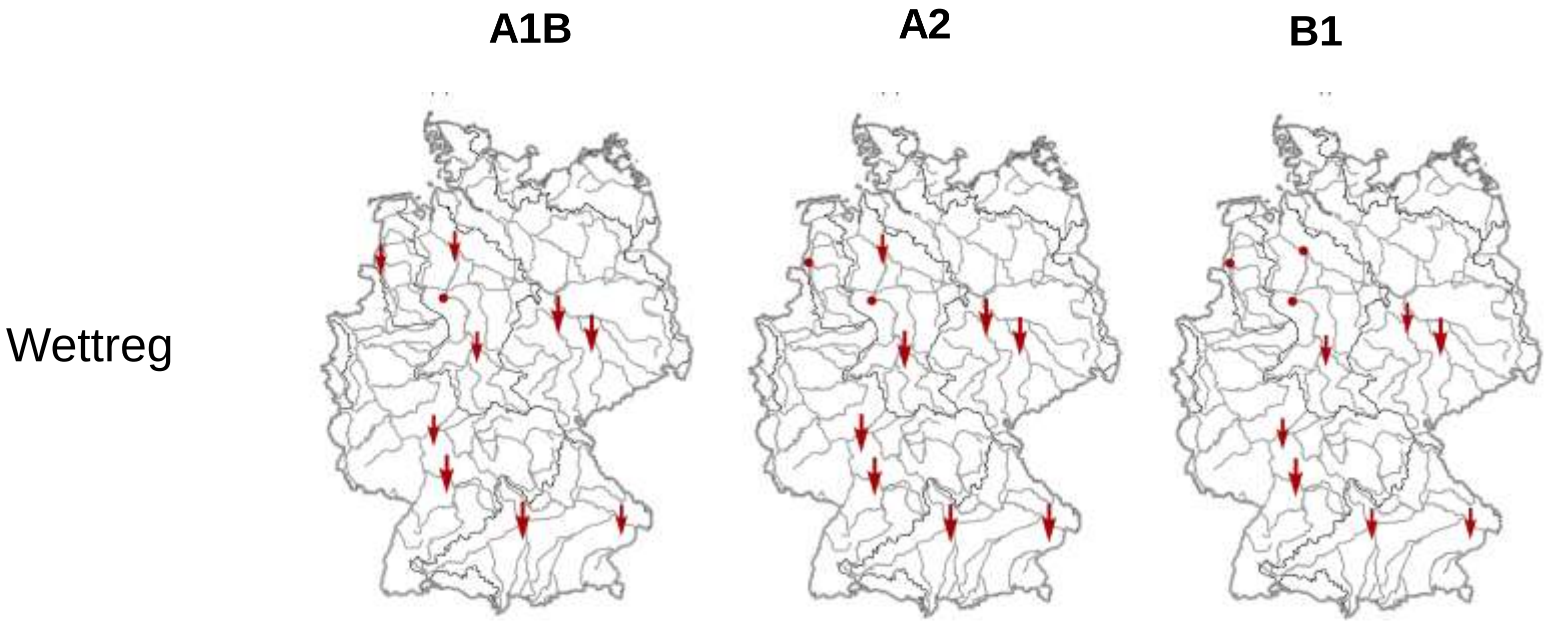
REMO

A1B, real. 1 A1B, real. 2 B1, real. 1 B1, real. 2

CCLM



Results - changes in 50-year low flow level



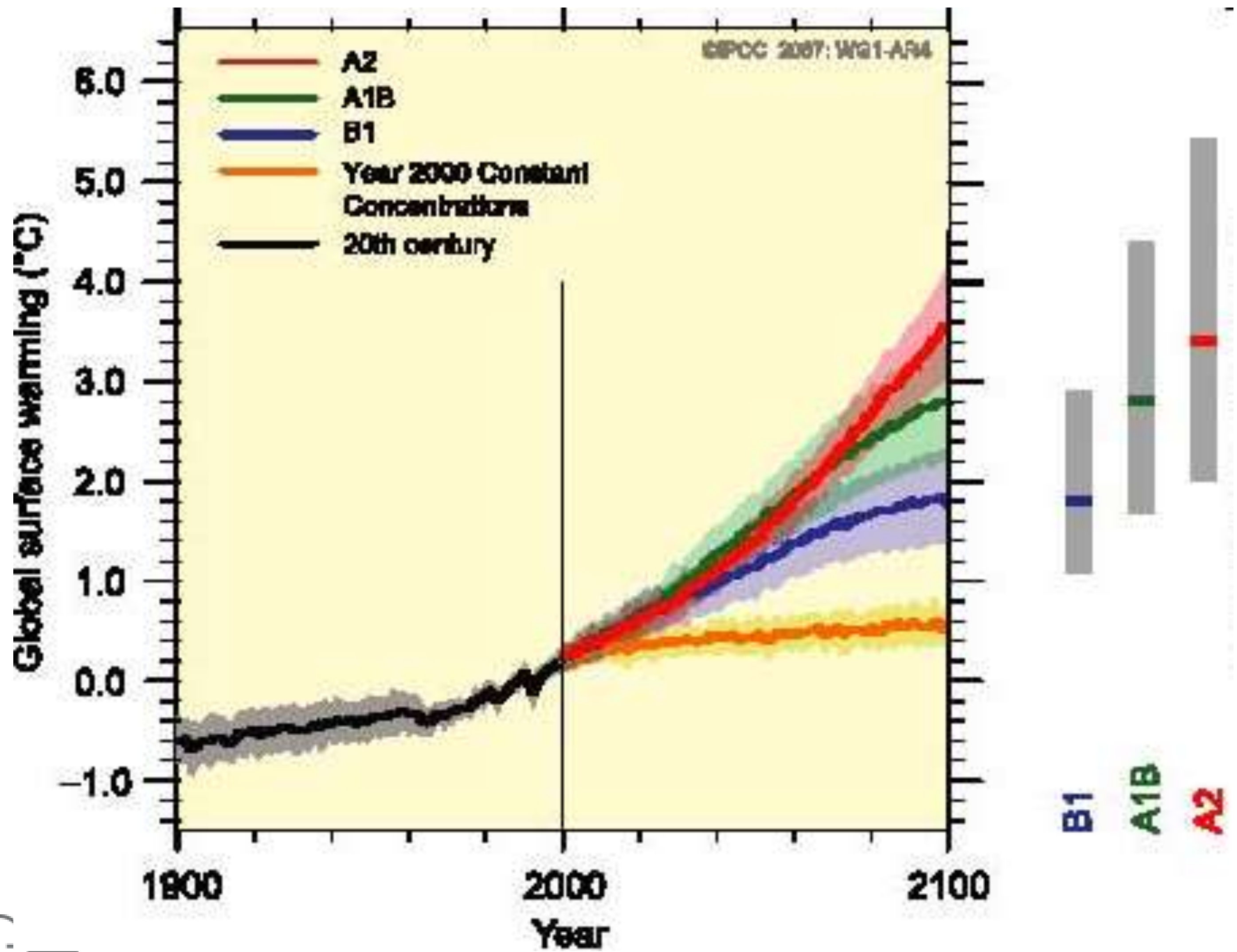
- Smaller uncertainty in low flow projections.
- Critical regions: German Danube and river Rhine.

Conclusion and outlook

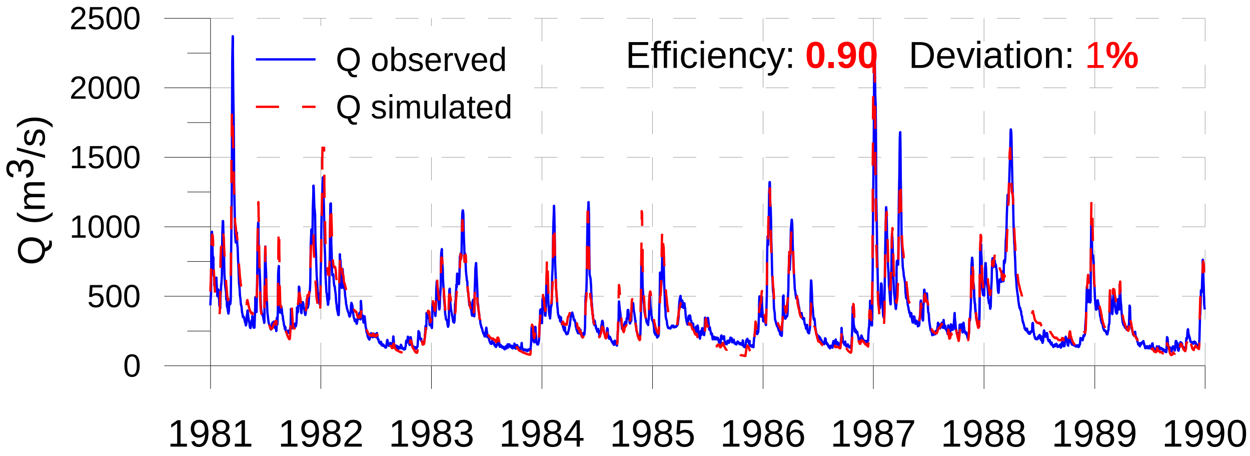
- Flood: large uncertainty, no distingt pattern
- Low flow: smaller uncertainty with decreasing trend in German Danube and river Rhine
- Future strategies:
  - **reduce the large uncertainty in flood projections**
  - **Apply other GCM driven scenarios**

Thank you for your attention!

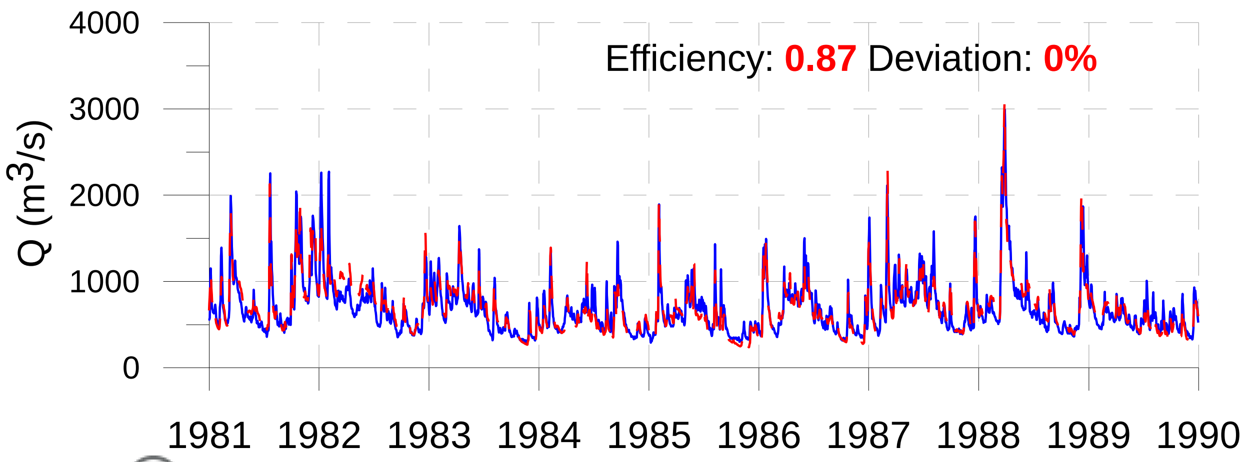
Dry river bed in Dresden in 2007
(Source: Reuters)

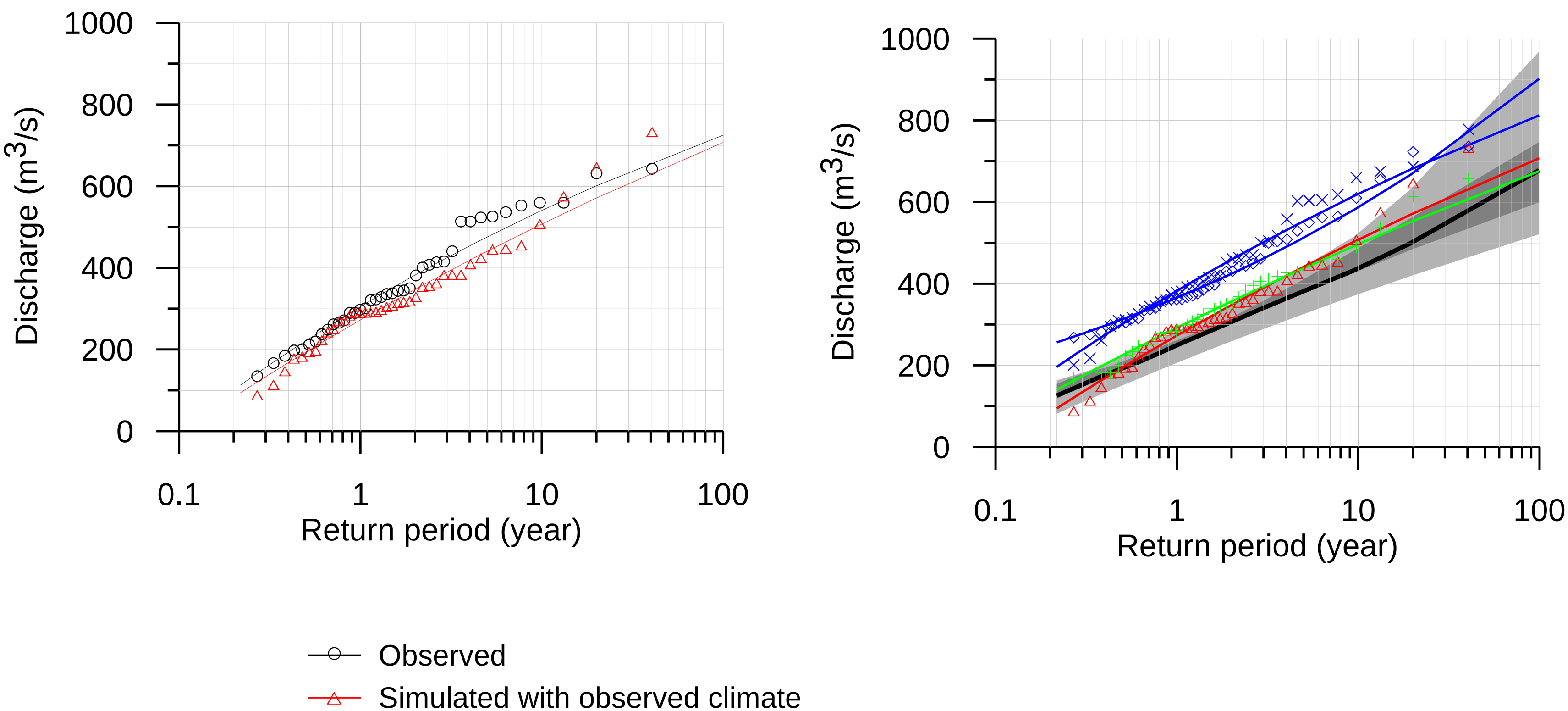

©IPCC 2007: WG1-AR4
A2
A1B
B1
Year 2000 Constant Concentrations
20th century
Global surface warming (°C)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
−1.0
1900
2000
2100
Year
B1
A1B
A2

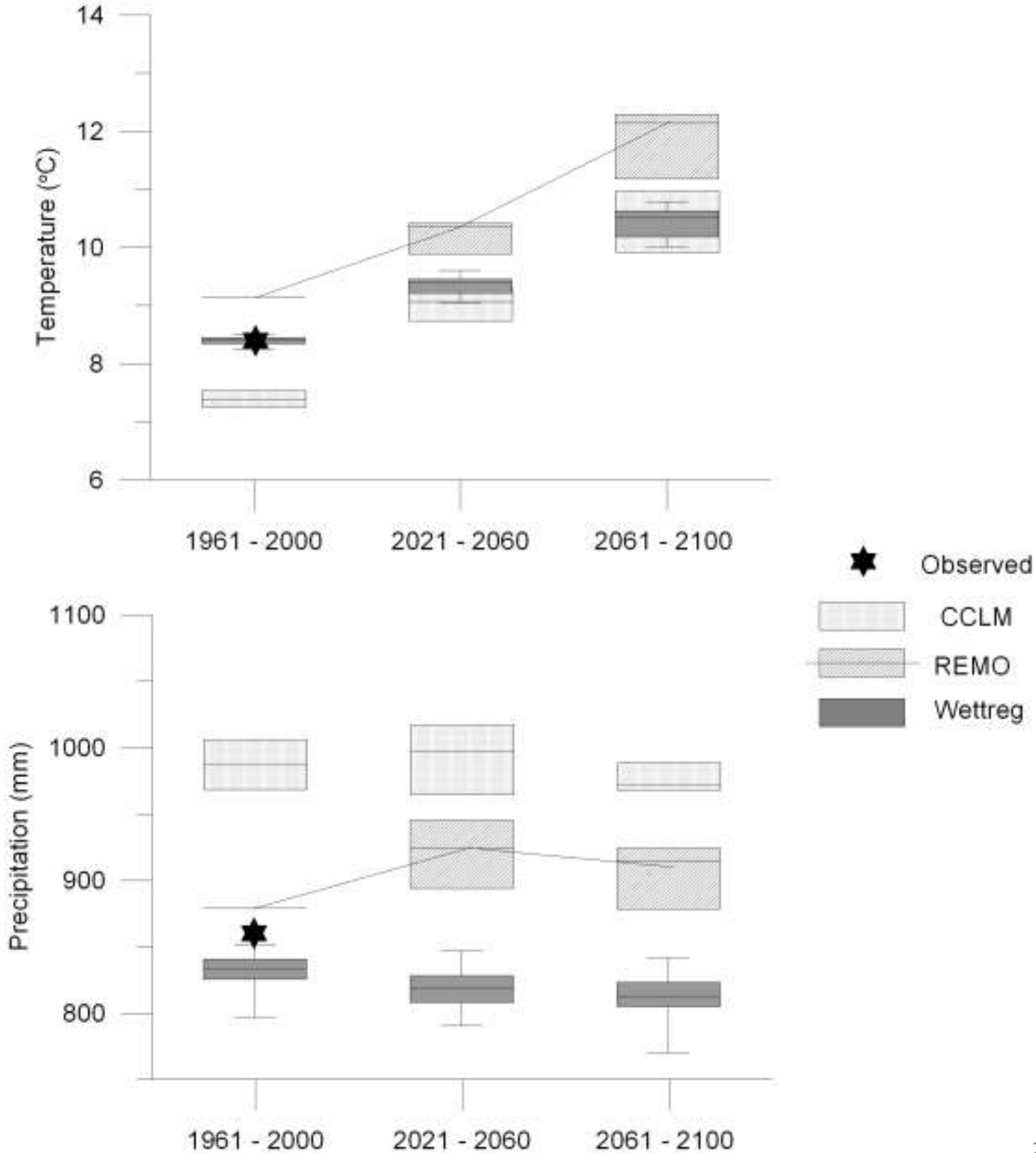
(a) Intschede (Weser)



(b) Hofkirchen (Danube)



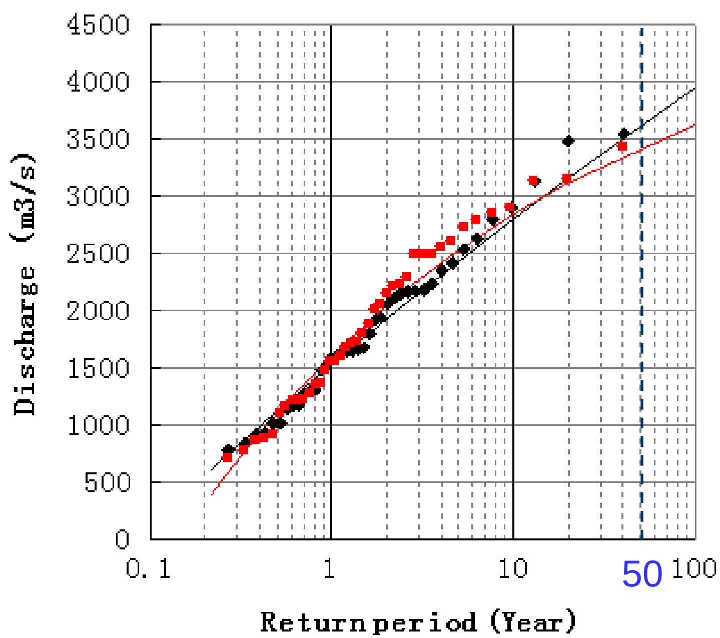

1000
800
600
400
200
0
0.1
1
10
100
Return period (year)
Discharge (m3/s)
Observed
Simulated with observed climate


14
12
10
8
6
Temperature (ºC)
1961 - 2000
2021 - 2060
2061 - 2100
Observed
CCLM
REMO
Wettreg
1100
1000
900
800
Precipitation (mm)
1961 - 2000
2021 - 2060
2061 - 2100

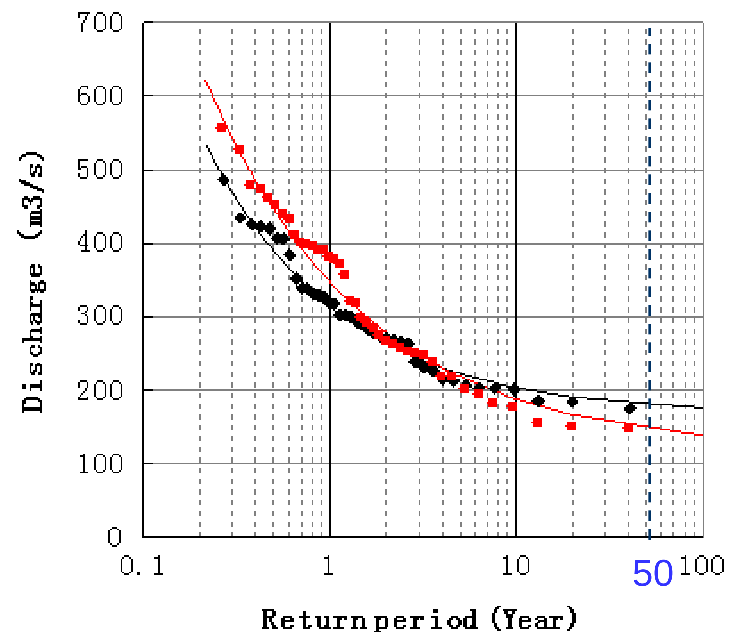
Result – calibration and validation: one example

Generalized Extreme Value (GEV) plots for the annual maxima of daily discharge and the annual minimum 7-day (AM7) mean flow observed and simulated during control period 1961 - 2000 at the gauge Neu Darchau (Elbe)

Annual maxima



Annual minimum 7-day mean flow

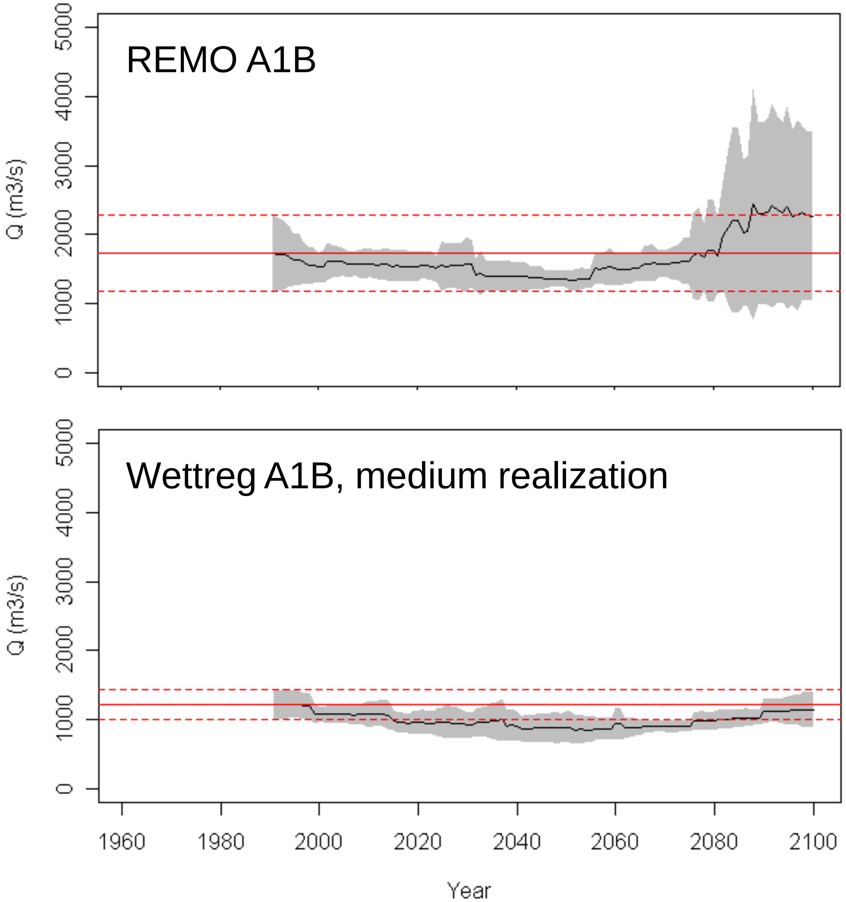


Observed

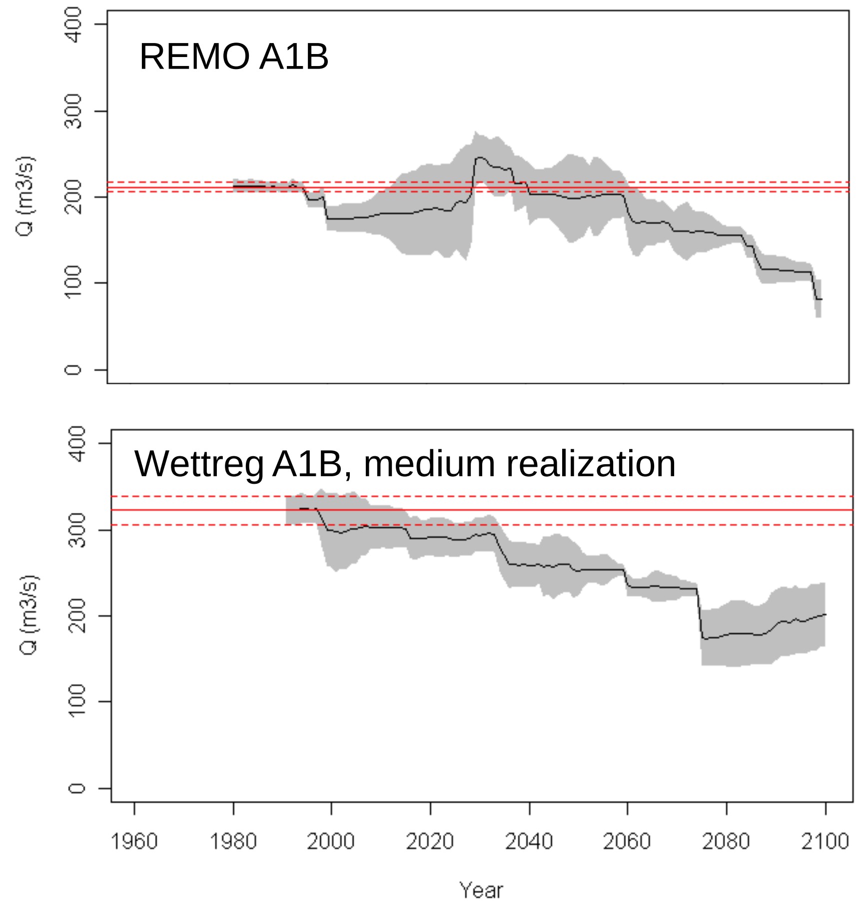
Simulated with observed climate

Results – flood/low flow generation over time

Intschede (Weser) Flood



Hofkirchen (Danube) Low flow

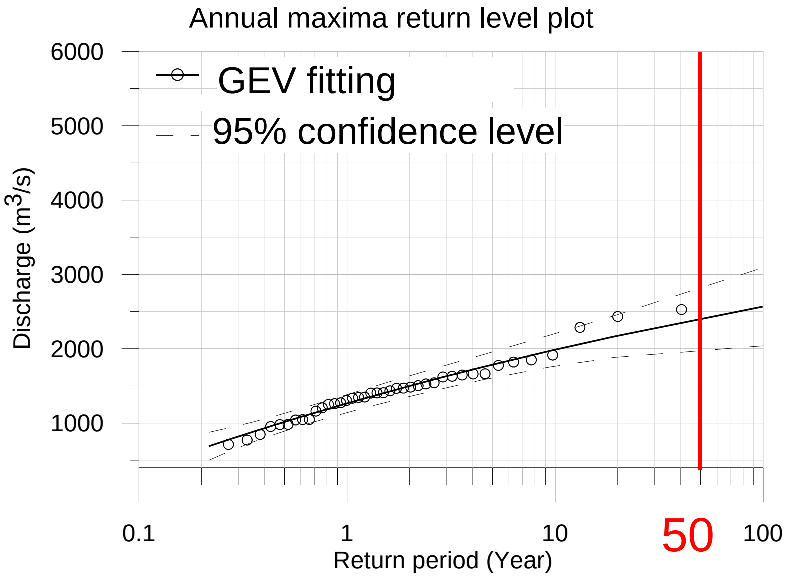


30-year flood/low flow level estimated

95% confidence level

30-year flood/low flow level for 1961 -1990

95% confidence level for 1961 -1990



Annual maxima return level plot
GEV fitting
95% confidence level
Discharge (m3/s)
6000
5000
4000
3000
2000
1000
0.1
1
10
50
100
Return period (Year)