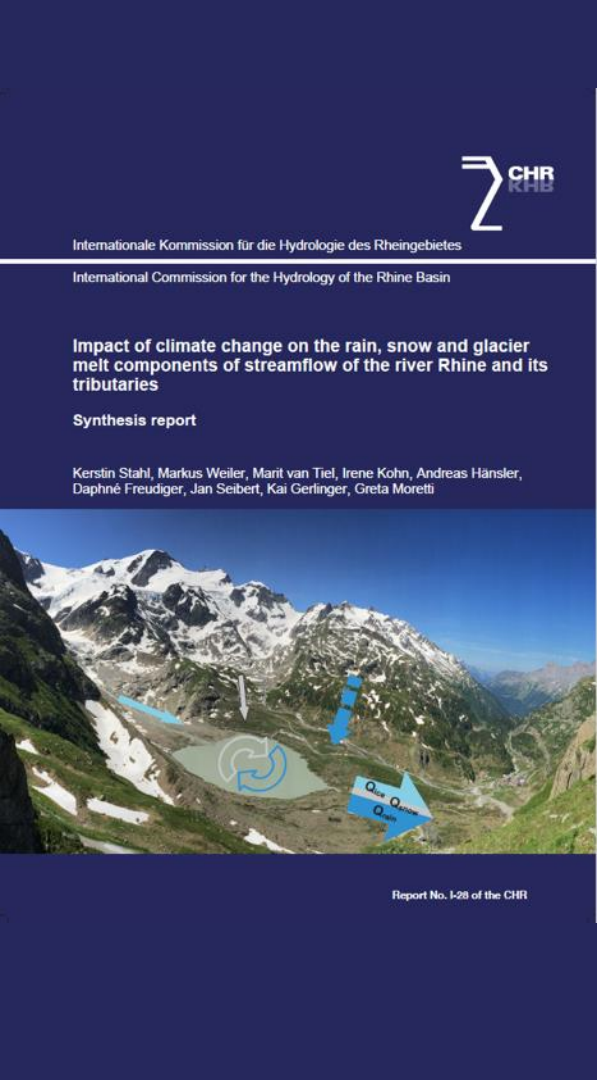

Bias correction of climate model data for hydrological impact modelling

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ASGII Symposium

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Identifying the ASGII RCM Ensemble (I)

- Using data from the high-resolution EURO-CORDEX RCM ensemble focusing on the most severe RCP8.5 scenario only
- Only limited number of transient hydrological simulations possible
  - Ensemble size was set to 7 different ensemble members
- Comparability of results from ASGII to previous projects (e.g. Hydro-CH2018, KLIWA)
  - A core ensemble of 4 RCM simulations (2 RCMs forced with 2 GCMs) was identified

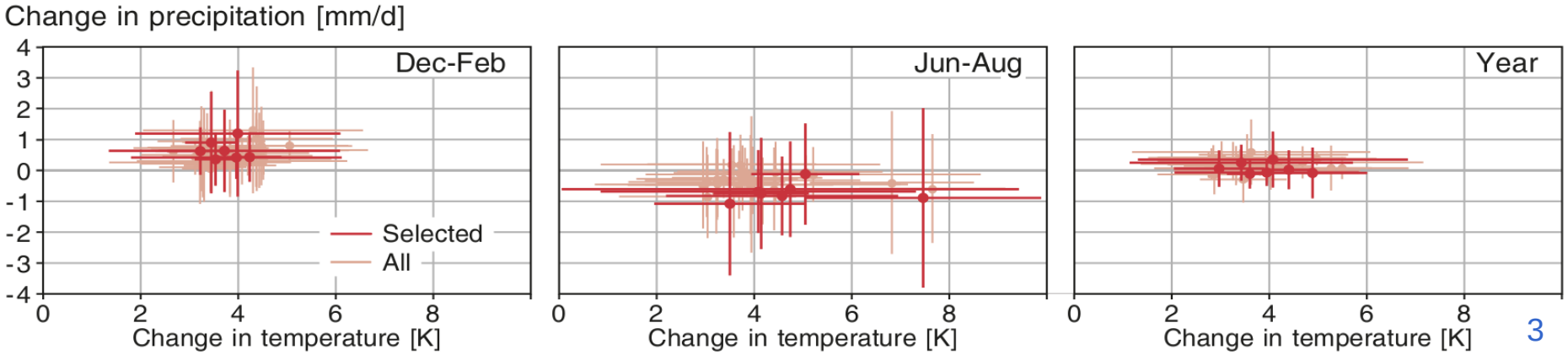
3 additional RCM simulations had to be identified at the start of ASGII

Identifying the ASGII RCM Ensemble (II)

- ASGII ensemble should reflect the spread in projected changes of the whole EURO-CORDEX ensemble
  - This includes a rather warm/dry outlier simulation
  - Since forcing GCM has major impact on regional CC signal over Europe, final ensemble consist of 2 RCMs and 5 GCMs

Table 1: Selected GCM-RCM combinations.

Global climate model	Regional climate model
CCCma-CanESM2	CLMcom-CCLM4-8-17
ICHEC-EC-EARTH	CLMcom-CCLM4-8-17
ICHEC-EC-EARTH	SMHI-RCA4
IPSL-IPSL-CM5A-MR	SMHI-RCA4
MIROC-MIROC5	CLMcom-CCLM4-8-17
MPI-M-MPI-ESM-LR	CLMcom-CCLM4-8-17
MPI-M-MPI-ESM-LR	SMHI-RCA4



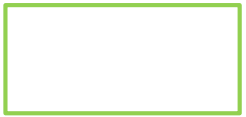
Bias RCMs Alpine Region

- Problem: RCM data generally large cold/wet bias over the alpine region mainly in winter
  - Would strongly impact snow accumulation

Bias–correction needed before data can be used as input for hydrological modelling

DJF - Temperature

DJF - Precip



Obs

All other panels: Changes rel. to Obs

Smiatek et al., 2016

Bias - Ensemble Mean

HYDROLOGY

Observations

Bias
uncorrected

Mean winter temperature

Mean annual snowfall*

*** Snowfall is defined as precipitation at days with daily mean temperature < 1 ° C**

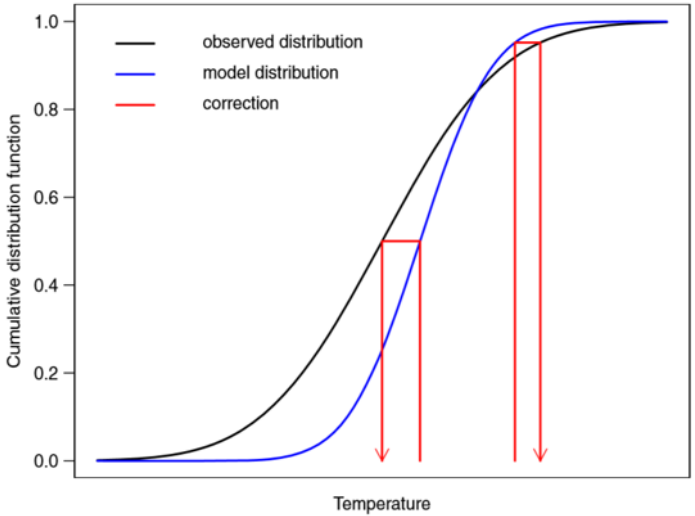
Bias Correction of RCM data:

HYDROLOGY

Challenges

- Removing the bias in the RCM data without:
  - Altering the inter parameter relation (e.g. temperature and rainfall on a snow day)
  - Changing the seasonality of the data
  - Changing the projected climate change signals of the RCM projection
  - Adding new extreme values to the RCM data

Principle behind QM: matching CDFs

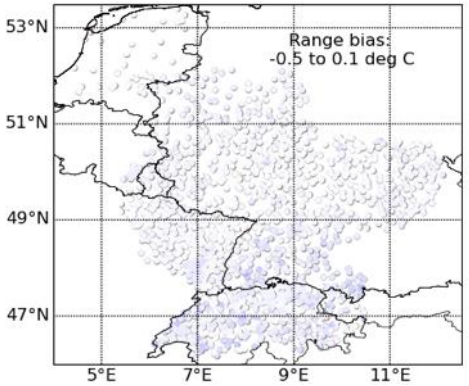
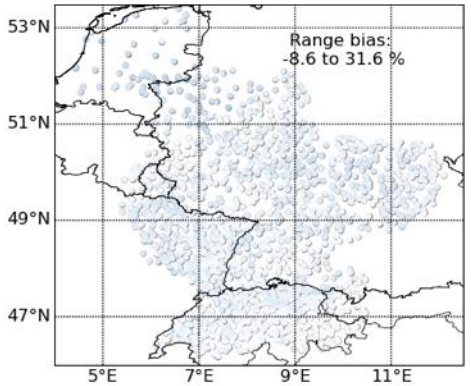


Graph taken from Maraun 2016

Solution

- Multi-variate, trend conserving quantile mapping bias correction method was applied for the different seasons-> tas, pr, humidity, rad were corrected simultaneously
- Results were analyzed for a large set of climate indices -> single & multi-parameter indices

Bias - Ensemble Mean

	Observations	Bias uncorrected	Remaining Bias corrected
Mean winter temperature			
Mean annual snowfall*			

Impact of BC on CC signal

- Visual comparison of cc signal at end of century before and after correction (whole basin)

Summary BC

- Large amount of RCM-bias removed
  - For individual indices, univariate correction might be better
  - But if interplay between parameters is important (e.g. hydrological models) multi-variate correction is better
- Trends and extremes of RCM data are mostly preserved

Index	EM 1	EM 2	EM 3	EM 4	EM 5	EM 6	EM 7
cdd_p95	X	~	~	~	~	~	~
dday_SUMMER	X	~	~	~	~	~	~
fday	✓	✓	✓	✓	✓	✓	✓
g30mmday	✓	✓	✓	✓	✓	✓	✓
heatday	✓	✓	✓	✓	✓	✓	✓
p5	✓	✓	✓	✓	✓	✓	✓
p95	~	✓	✓	✓	✓	✓	✓
pr_DJF	✓	✓	✓	✓	✓	✓	✓
pr_JJA	✓	✓	✓	✓	✓	✓	✓
pr_YEAR	✓	✓	✓	✓	✓	✓	✓
psum_hot	~	~	~	~	~	~	~
psum_warm	~	~	~	~	~	~	~
samount	~	~	~	~	~	~	~
sday	~	~	~	~	~	~	~
sdd_p95	✓	✓	✓	✓	✓	✓	✓
summerday	~	~	~	~	~	~	~
tas_DJF	✓	✓	✓	✓	✓	✓	✓
tas_JJA	✓	✓	✓	✓	✓	✓	✓
tas_YEAR	✓	✓	✓	✓	✓	✓	✓
zdays	~	~	~	~	~	~	~

~: almost no difference; ~: moderate difference; X: substantial difference

Projected future climate – ensemble mean

Reference

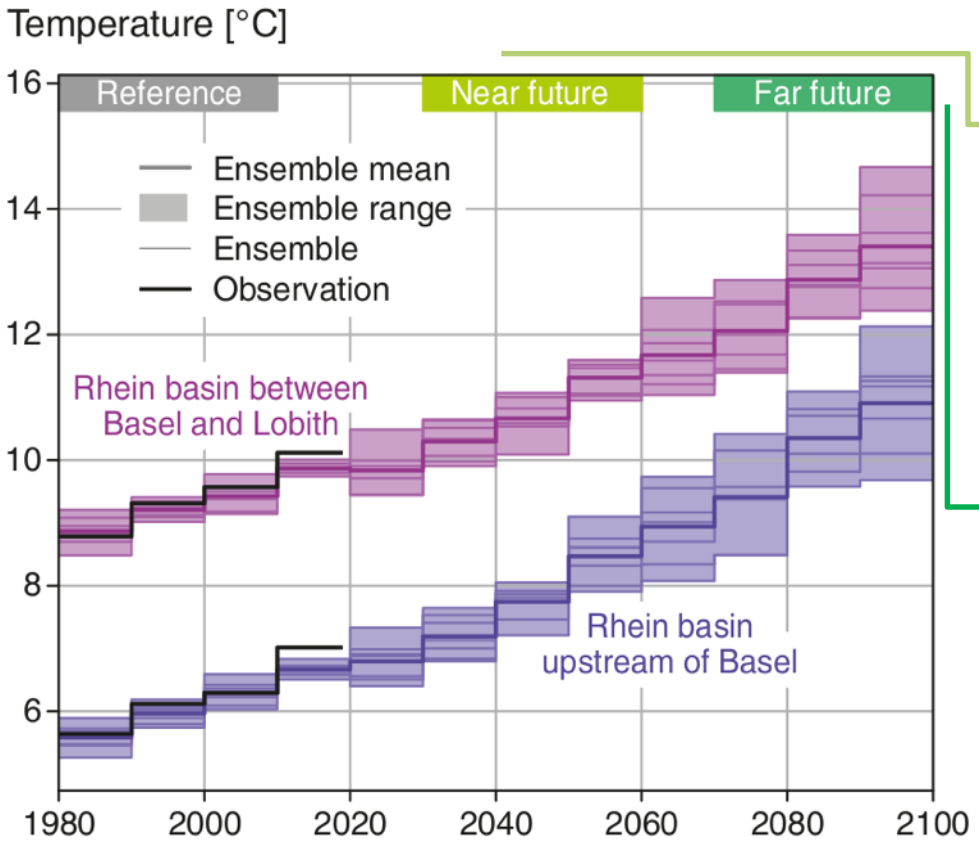
Projected changes
Far future

Mean annual snowfall*

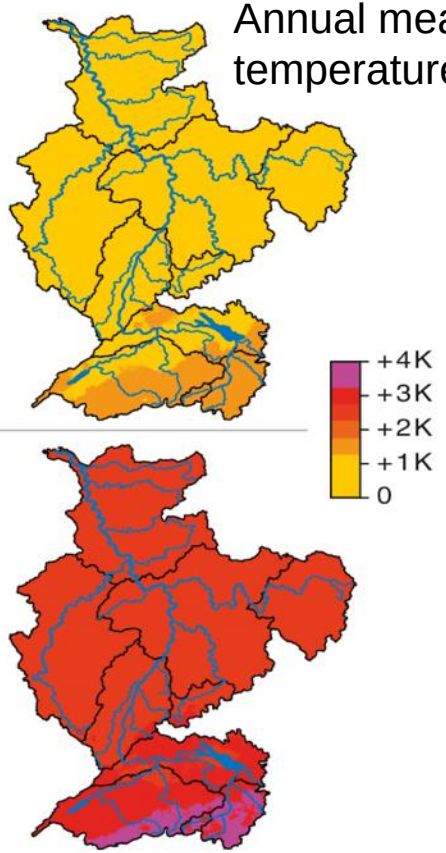
Mean number of frost days

*** Snowfall is defined as precipitation at days with daily mean temperature < 1 ° C**

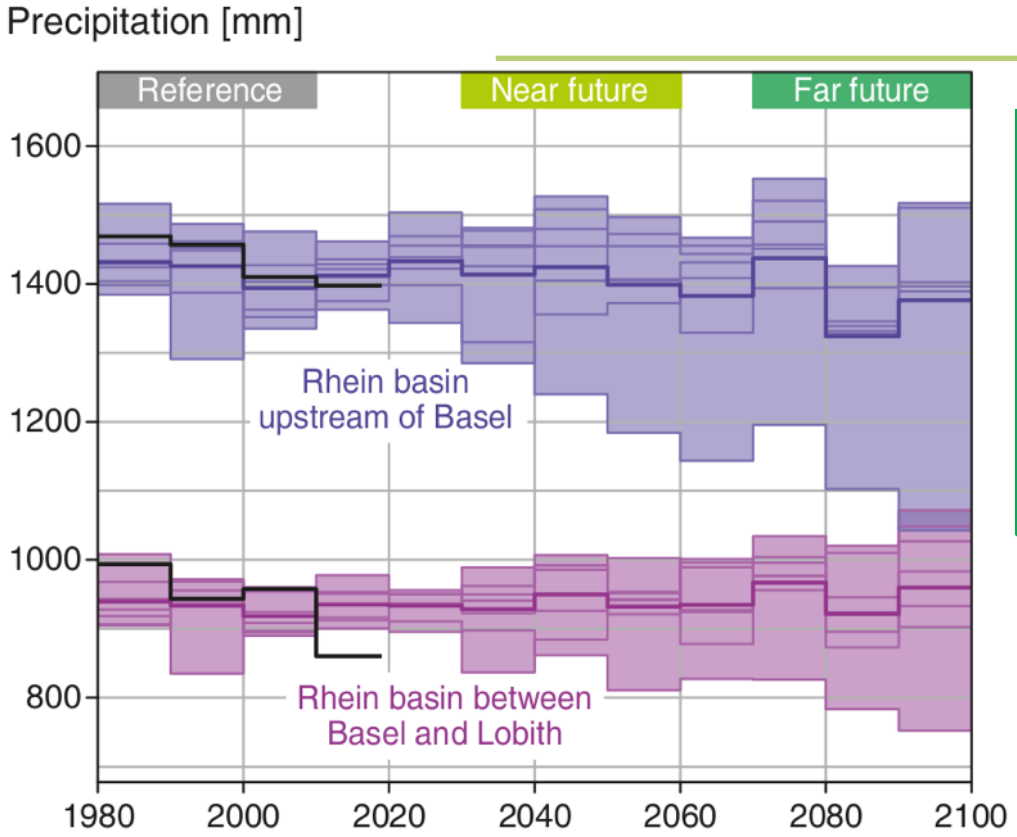
Projected future climate – range & map of ensemble mean T

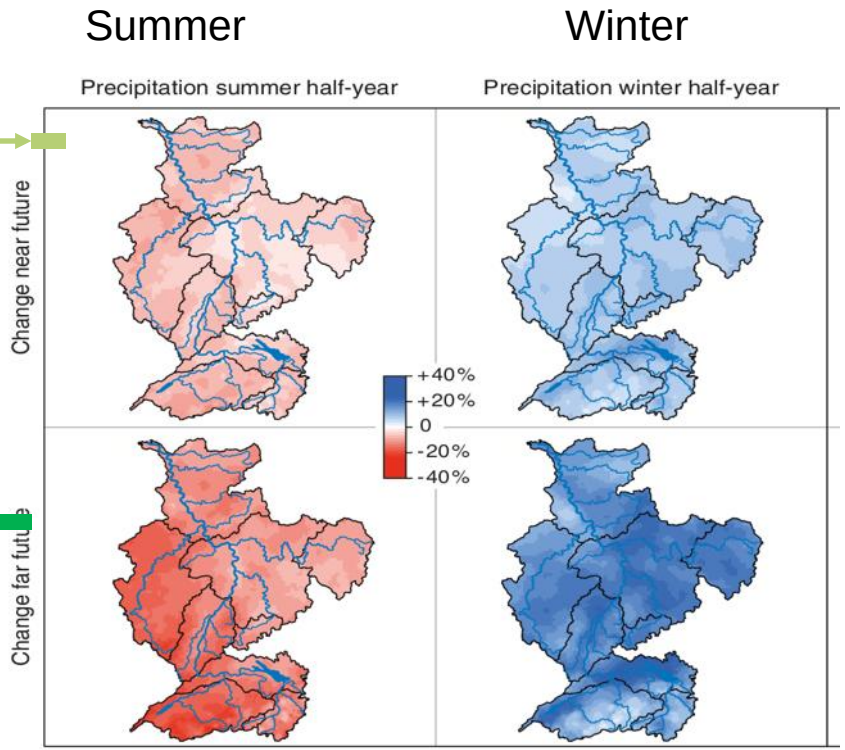


Annual mean temperature change



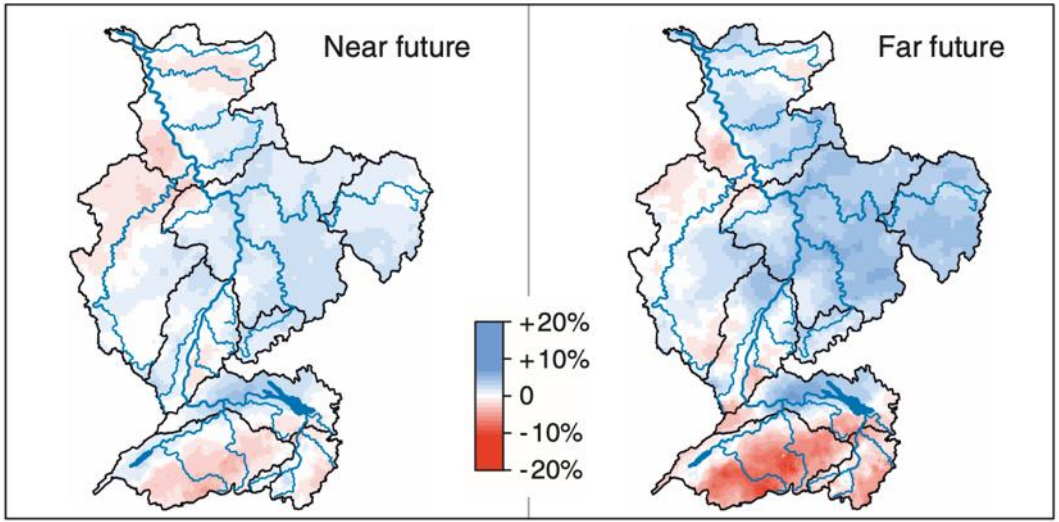
Projected future climate – range & maps of ensemble mean P

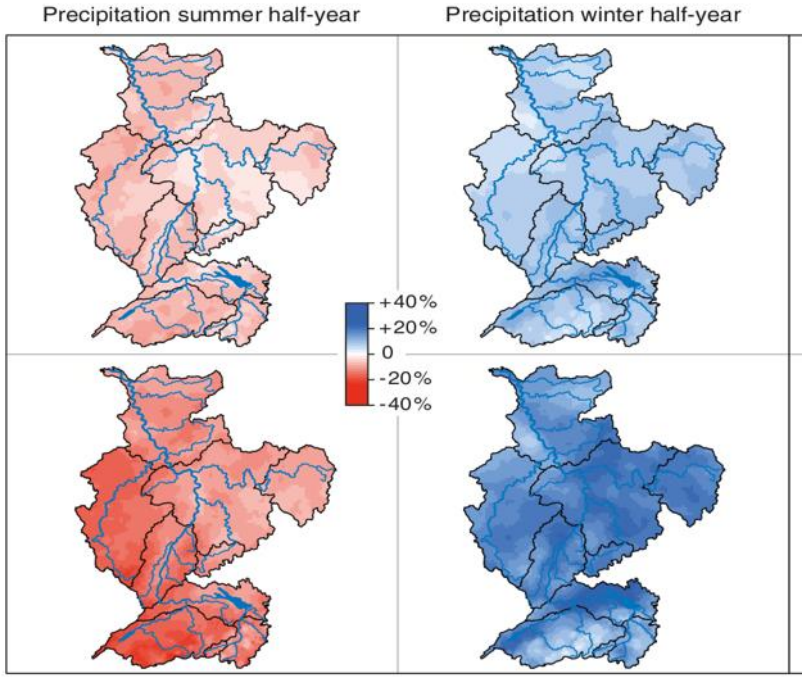




Projected future climate – maps of ensemble mean P

→ important pattern: annual P change!



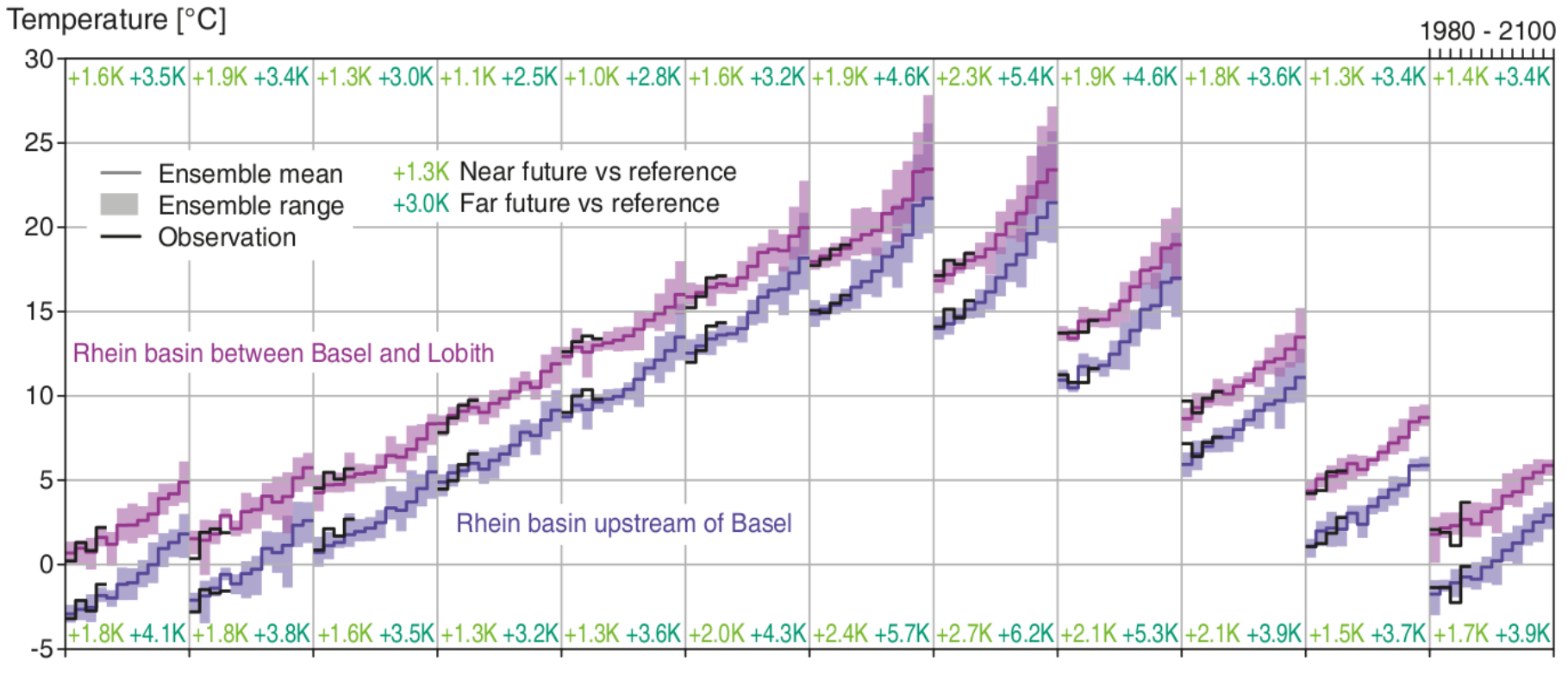


Summary

- ASGII Climate model ensemble selected to guarantee comparability to previous activities in the Rhine basin and to reflect the spread of projected changes of the full EURO-CORDEX ensemble
- Bias correction using multi-variate QM method lead to substantially less biased RCM data thereby conserving inter-parameter dependencies as well as projected trends and extremes
- The ensemble represents already known patterns of projected changes like:
  - Substantial increase in projected air temperature in the range from +4 to +8K by the end of the century
  - An increase in winter precipitation but a decrease in summer precipitation
  - Connected to these changes are e.g. an increase in heat waves, a decrease in the number of frost days as well as a decrease in projected snowfall amounts

Backup Slides

Projected seasonal changes



Projected seasonal changes

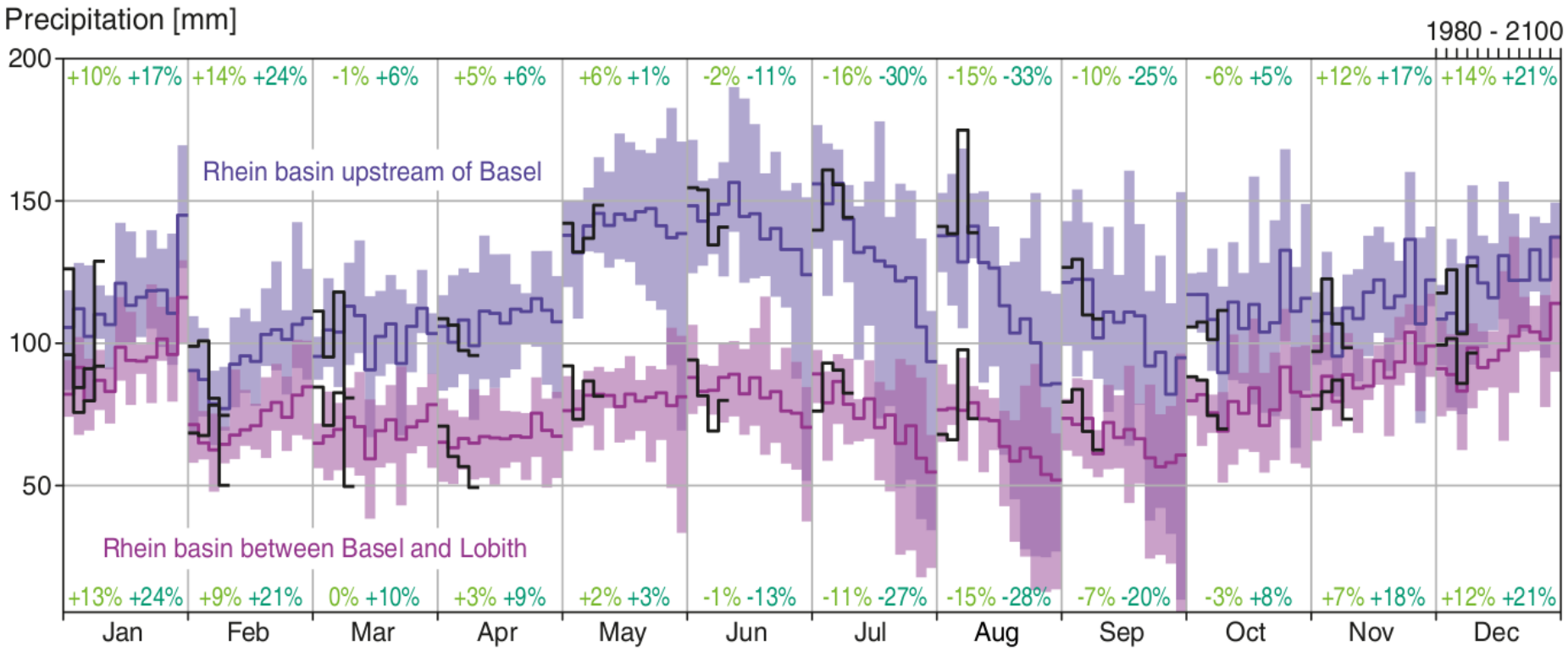


Figure 7: Time series 1981–2100 for each month in each compartment: 10-year averages of mean monthly temperature (upper) and precipitation sum (lower), averaged in space for the Rhine basin upstream of the gauge Basel and for the Rhine basin between gauges Basel and Lobith; black lines show the observed climate data until 2019.