A method of correction of regional climate model data for hydrological modelling

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The aim of this study was to provide reasonable meteorological input data for the hydrological models to predict river run-off changes in the future.

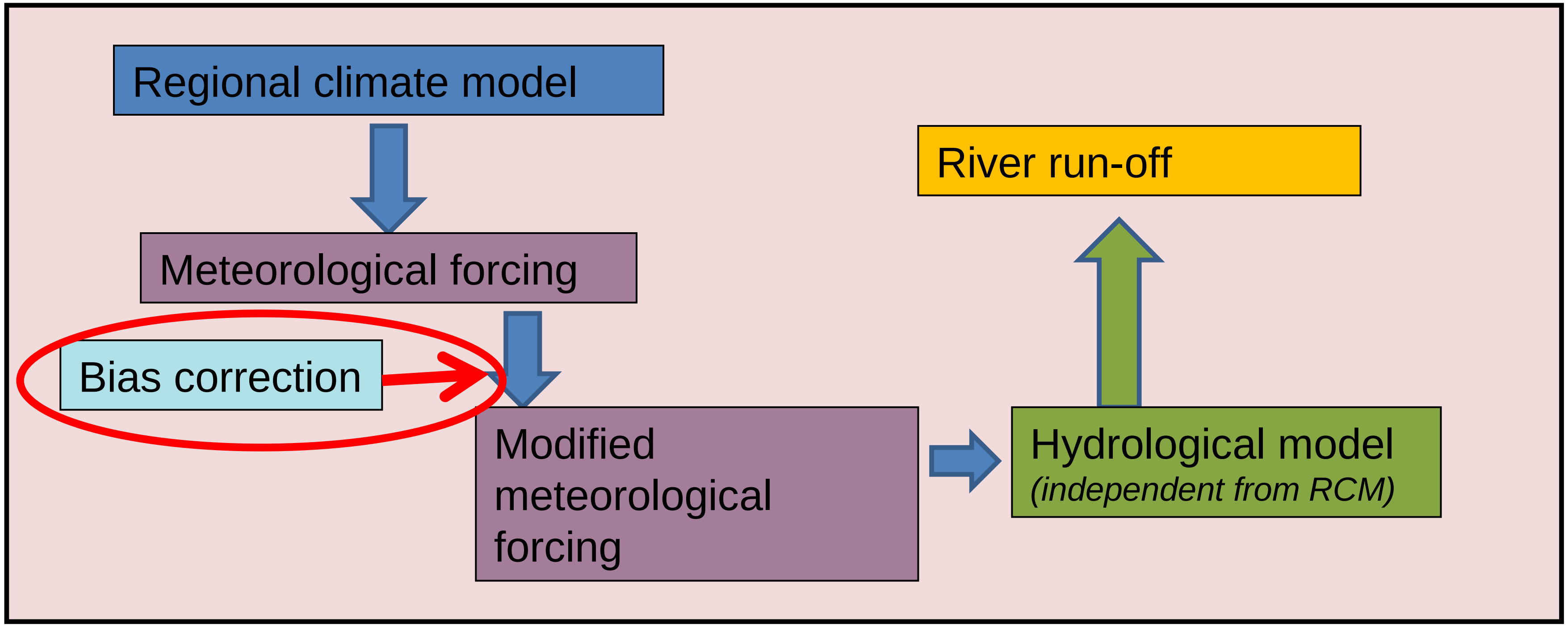
Regional climate model data from PRUDENCE project were analysed and bias corrected.

The goal of bias correction is to obtain daily time-series of modified temperature and precipitation at any point throughout the domain of our interest

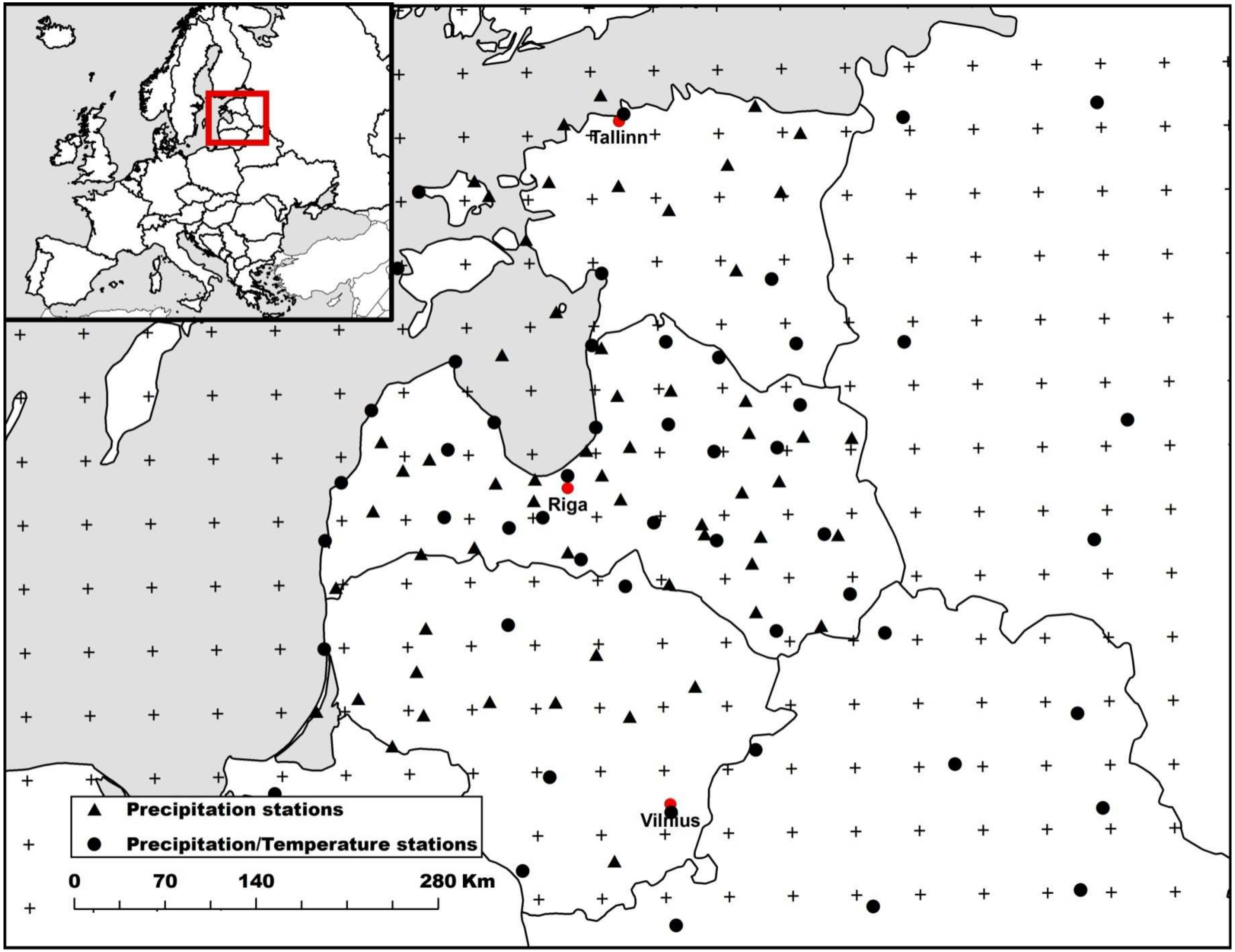
Introduction

The regional climate models (RCM) provide an information for the hydrological modelling of impact of expected climate change on the river run-off.

One must avoid direct usage of RCM data for the forcing of hydrological models without analysing RCM compliance with observations for the control period.



Region of study



Regional climate model data

We considered a set of regional climate model runs for Europe from the PRUDENCE project.

> *"PRUDENCE is a European FP5 scientific project to quantify confidence and the uncertainties in predictions of future climate and its impacts, using an array of climate models."*

21 of the model runs (experiments) were analysed for their biases with observation data in the region. 4 of them are used for bias correction.

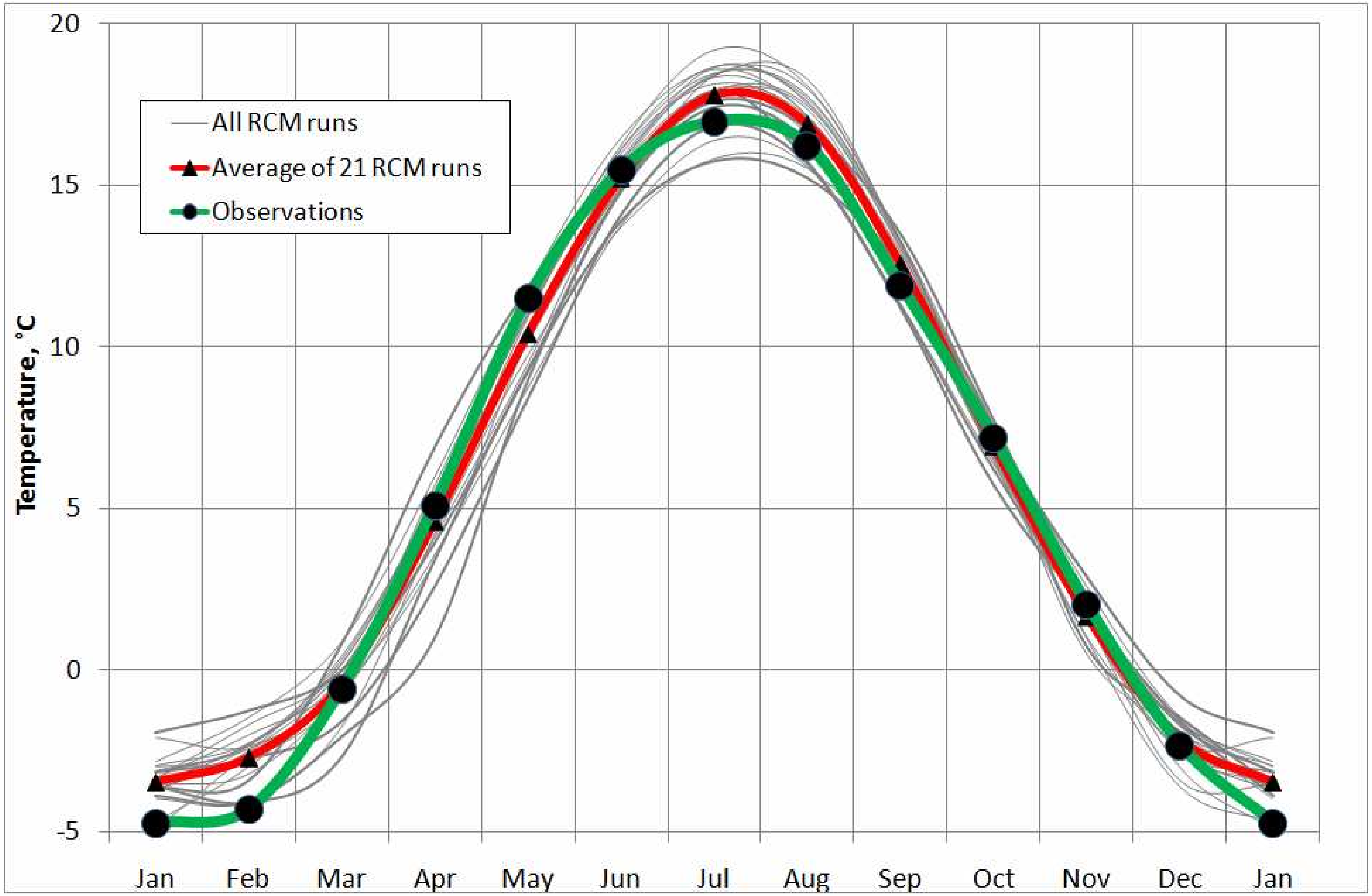
Observation data

Data for the control period (1961-1990) at 118 observation stations were considered

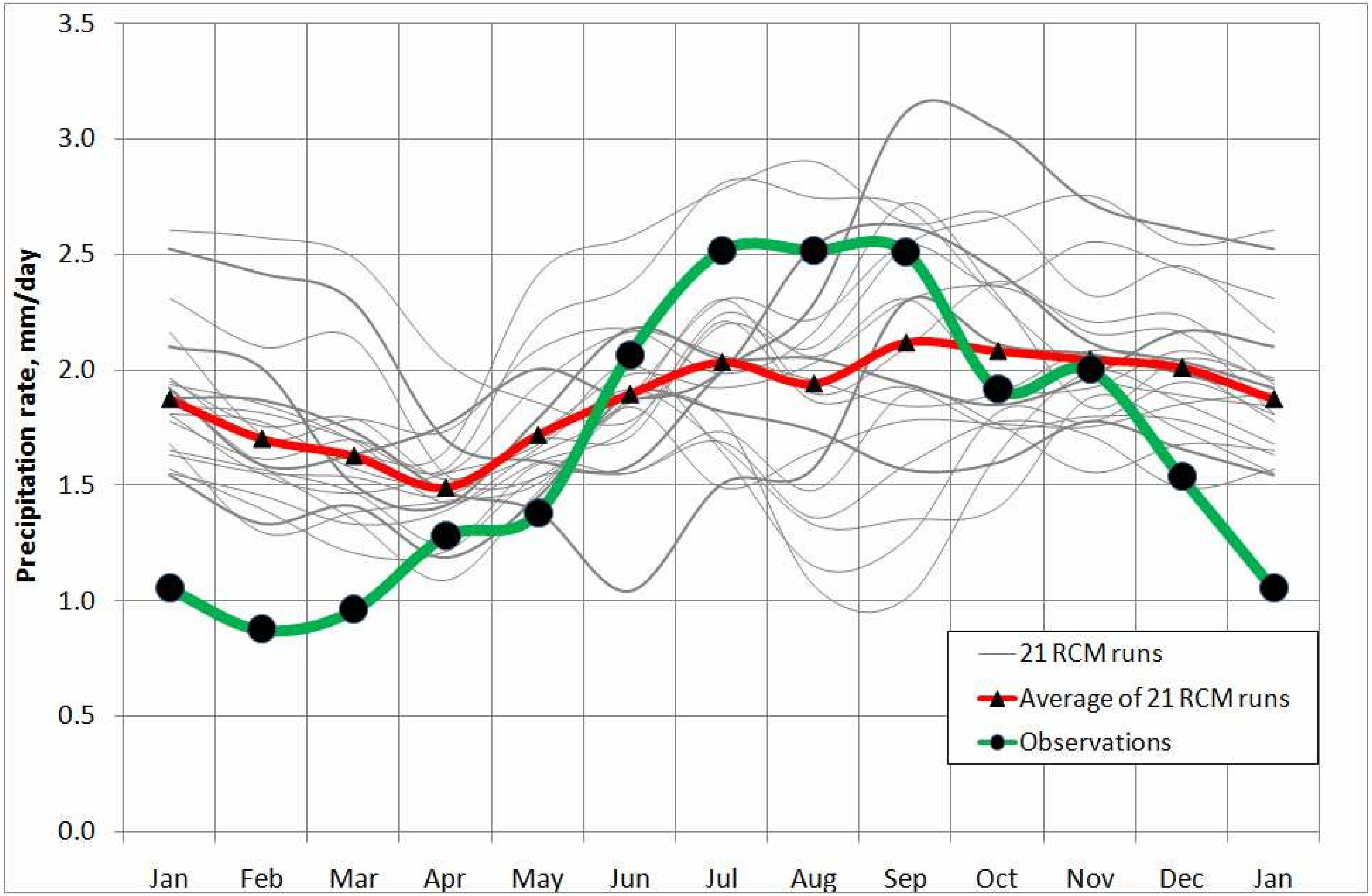
Sources:

- *Latvian Environmental, Geological and Meteorological Agency*
- *European Climate Assessment & Dataset*

Typical biases of temperature



Typical biases of precipitation



Modification algorithm

The bias correction method relies on changing of cumulative distribution function (CDF) of modelled data.

We apply similar corrections separately for temperature and precipitation.

We use CDFs constructed for each day of the year in 11-day moving time window.

CDF’s are constructed at each observation station both for observed data and RCM control period data. RCM time-series are interpolated to observation station positions.

Differences of observed and RCM CDF’s can then be interpolated to any point in the domain.

We obtain modified time-series of T/P for control period

Assuming stationarity of transformation we can obtain also modified time-series of T/P for future periods.

Modification algorithm

1. At each station, for each day-of-the-year, for each parameter (x):

Get $\mathbf{F_{obs}(x), F_{ctl}(x)}$

Get $\mathbf{\Delta x(F)=x_{modctl}-x_{ctl}=F^{-1}_{obs}(F_{ctl}(x_{ctl}))\ -x_{ctl}}$

2. Interpolate $\mathbf{\Delta x(F)}$ to the point of interest

3. Obtain modified time-series for control period at particular point

Interpolate RCM time-series, construct $\mathbf{F_{ctl}(x)}$

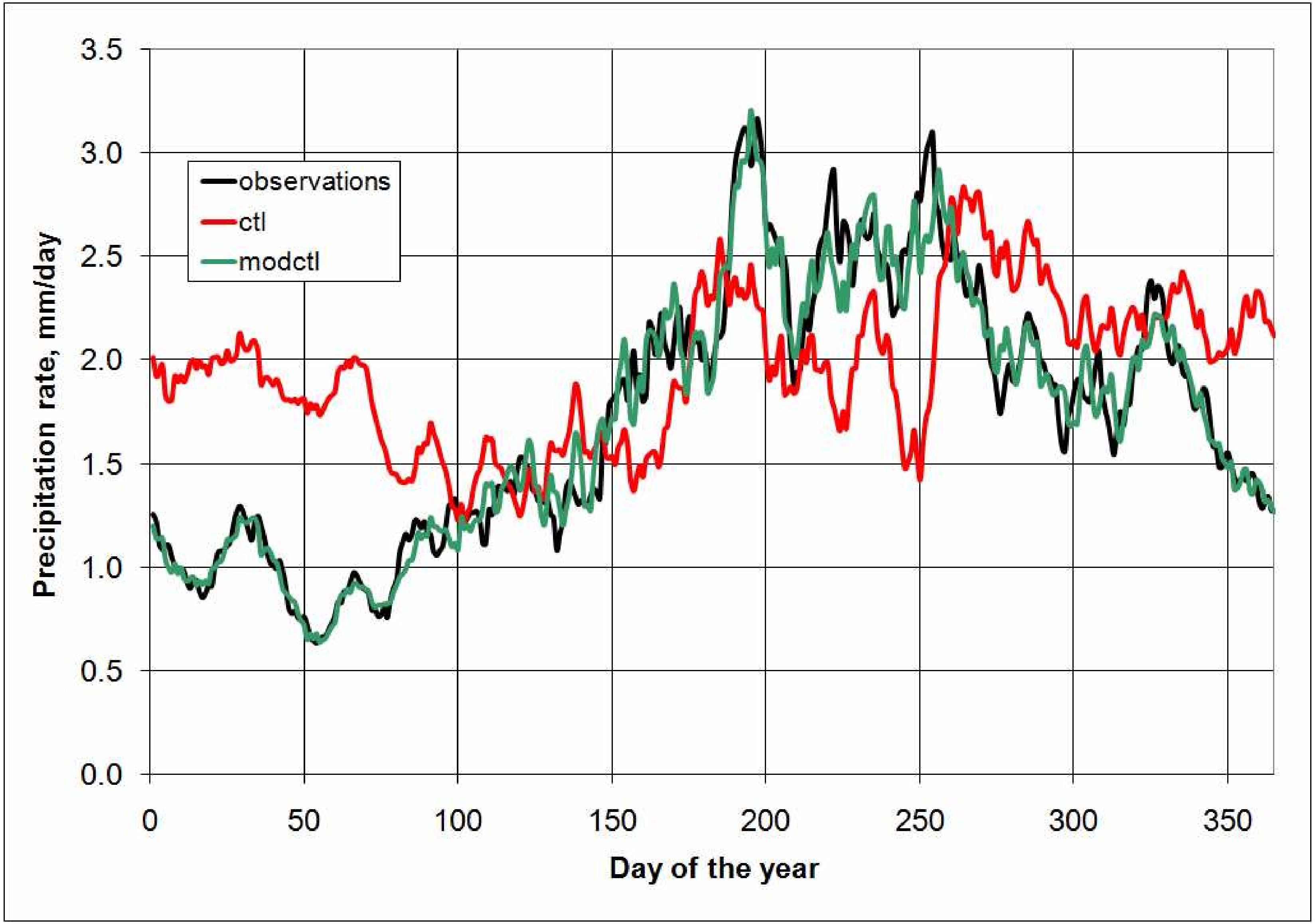
$\mathbf{x_{modctl}=x_{ctl}+\Delta x\ (F_{ctl}(x_{ctl}))}$

4. Obtain modified time-series for future scenarios at particular point

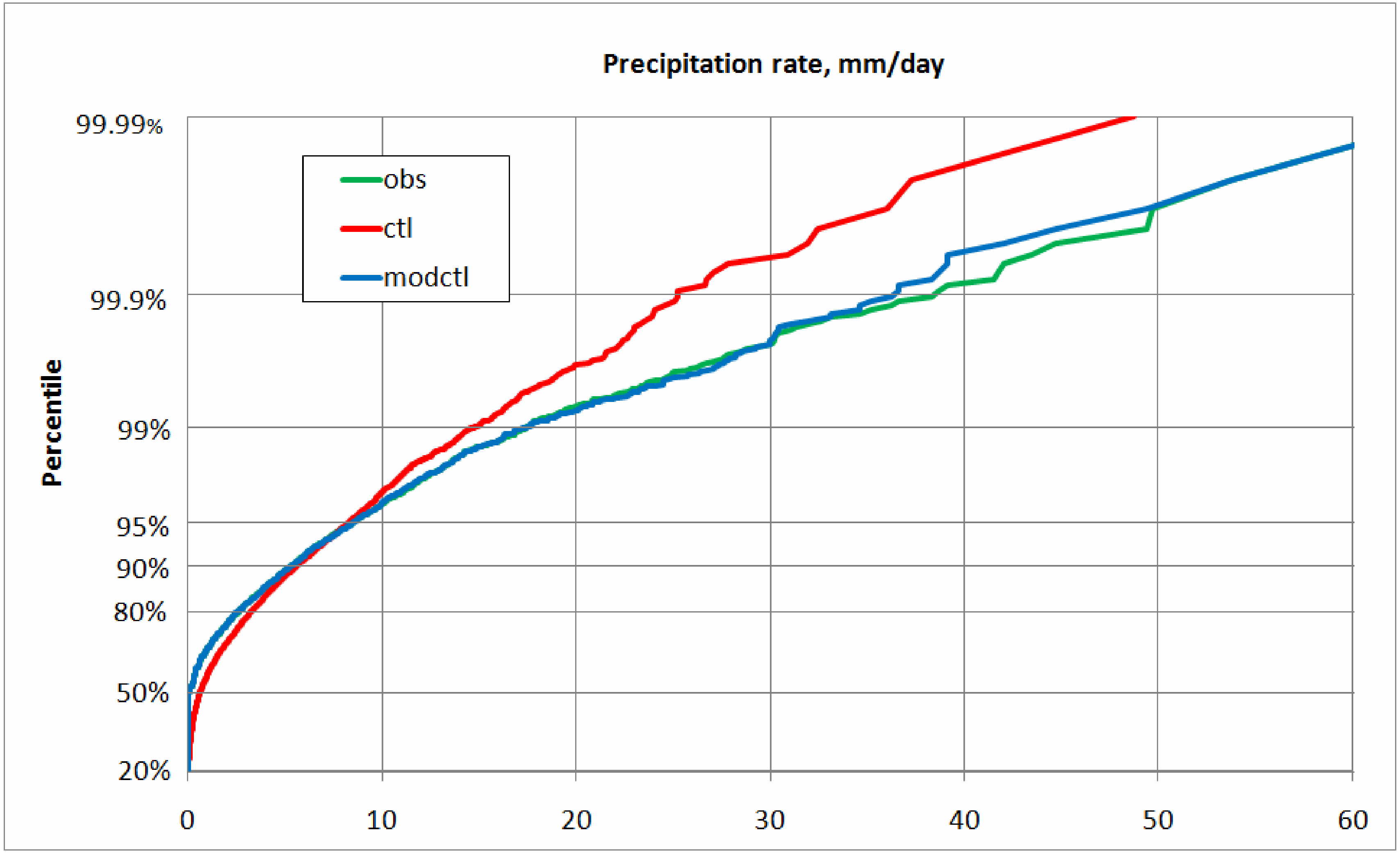
Interpolate RCM time-series, construct $\mathbf{F_{scen}(x)}$

$\mathbf{x_{modscen}=x_{scen}+\Delta x\ (F_{scen}(x_{scen}))}$

11-day moving average daily precipitation amount



Cumulative distribution function of precipitation



Monthly average statistical parameters

	Units	Organisation	KNMI		DMI		ETH		SMHI	
		Model	RACMO		HIRHAM		CHRM		RCAO	
		Run	HC1		ECC		HC_CTL		HCCTL	
		Abbreviation	orig	mod	orig	mod	orig	mod	orig	mod
Temperature	°C	MBE	0.94	0.00	0.79	0.00	-0.43	0.00	0.61	-0.03
	°C	RMSE monthly average	1.35	0.04	1.03	0.06	1.24	0.03	0.94	0.10
	°C	RMSE STDEV	0.50	0.05	0.46	0.05	0.97	0.06	0.64	0.10
	°C	RMSE interannual	0.57	0.37	0.36	0.26	0.56	0.30	0.53	0.37
Precipitation	mm/day	MBE	0.00	0.00	-0.19	-0.01	0.16	-0.01	0.23	0.00
	mm/day	RMSE monthly average	0.45	0.06	0.51	0.04	0.52	0.06	0.54	0.05
	%	RMSE CV	36%	6%	52%	10%	38%	8%	44%	9%
	%	RMSE Interannual CV	15%	13%	12%	10%	12%	11%	9%	10%
	%	RMSE Pdry	17%	1%	23%	1%	21%	1%	22%	1%
	mm/day	RMSE intensity	1.08	0.12	1.82	0.09	1.16	0.13	1.19	0.13
	mm/day	RMSE 95% percentile	1.94	0.52	3.25	0.44	2.29	0.29	1.75	0.56
	mm/day	RMSE 98% percentile	3.08	0.81	5.64	0.81	3.33	0.46	3.08	0.74
	-	RMSE of T/P correl. coeff	0.14	0.13	0.13	0.11	0.12	0.12	0.13	0.10

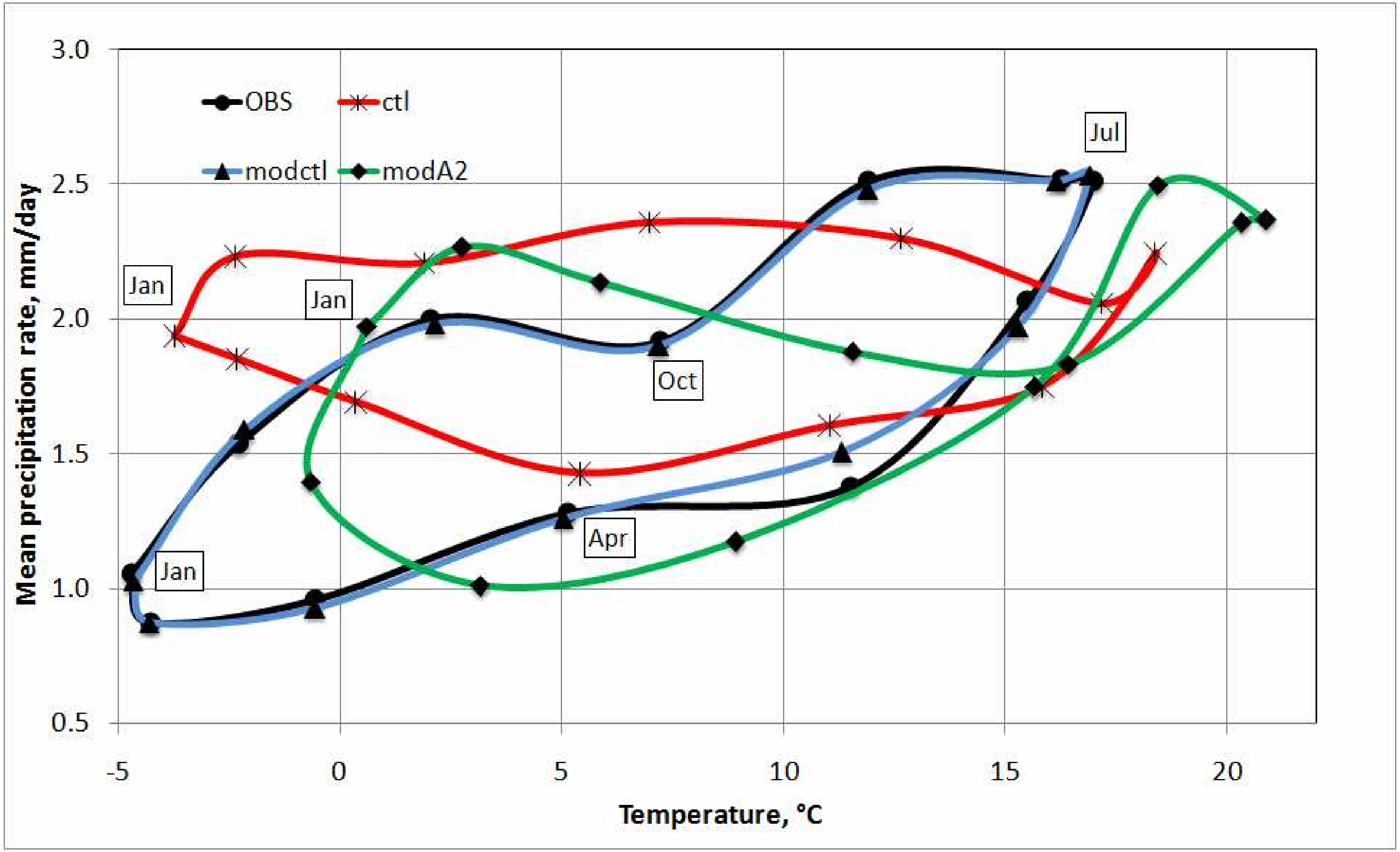
$$RMSE_x = \left(\frac{1}{12} \sum_m (x_m^{obs} - x_m^{mod})^2 \right)^{0.5}$$

Interannual – stdev of monthly average values

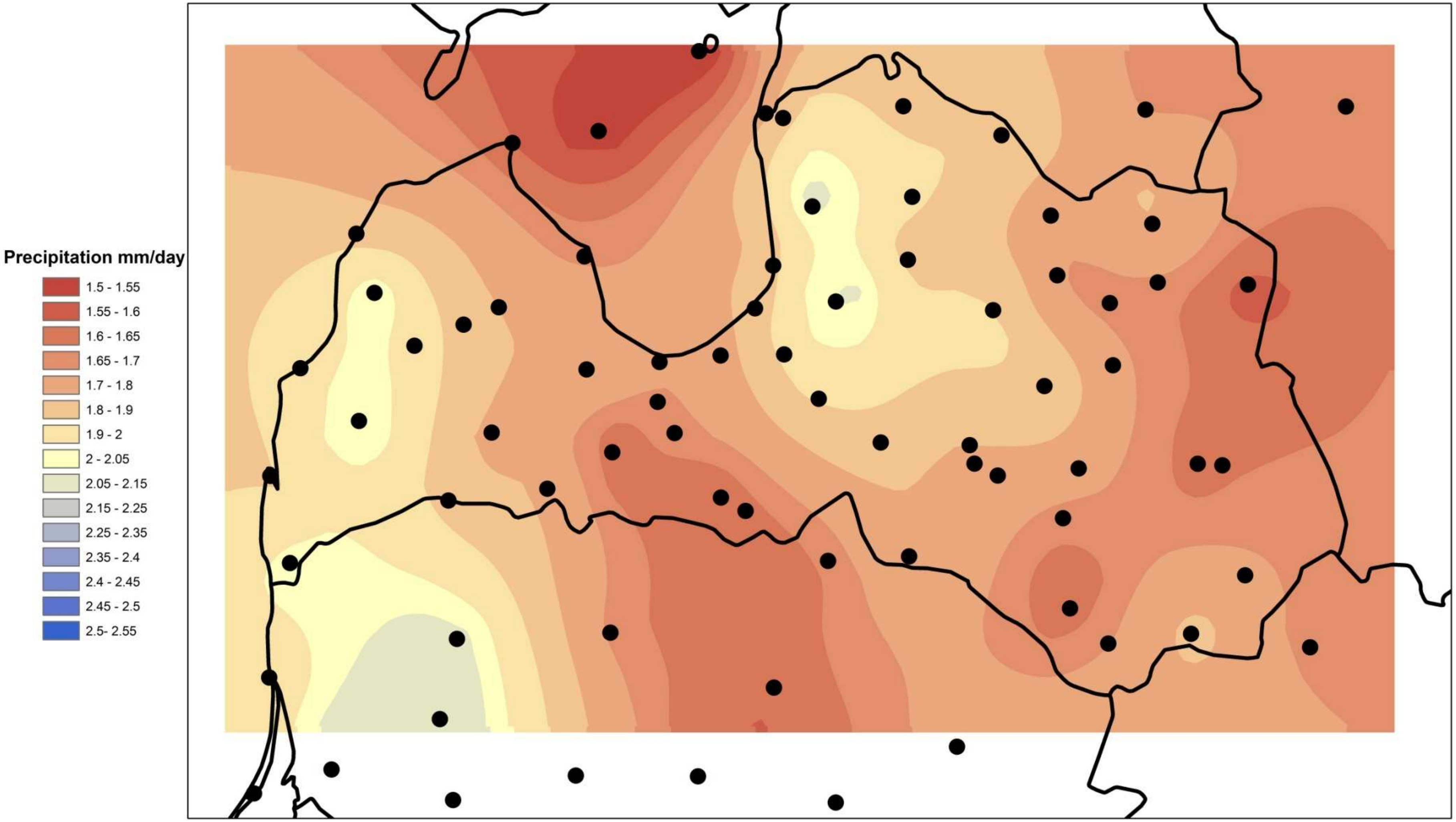
STDEV - stdev of daily values for a particular month

CV=stdev/ave

Monthly average temperature and precipitation

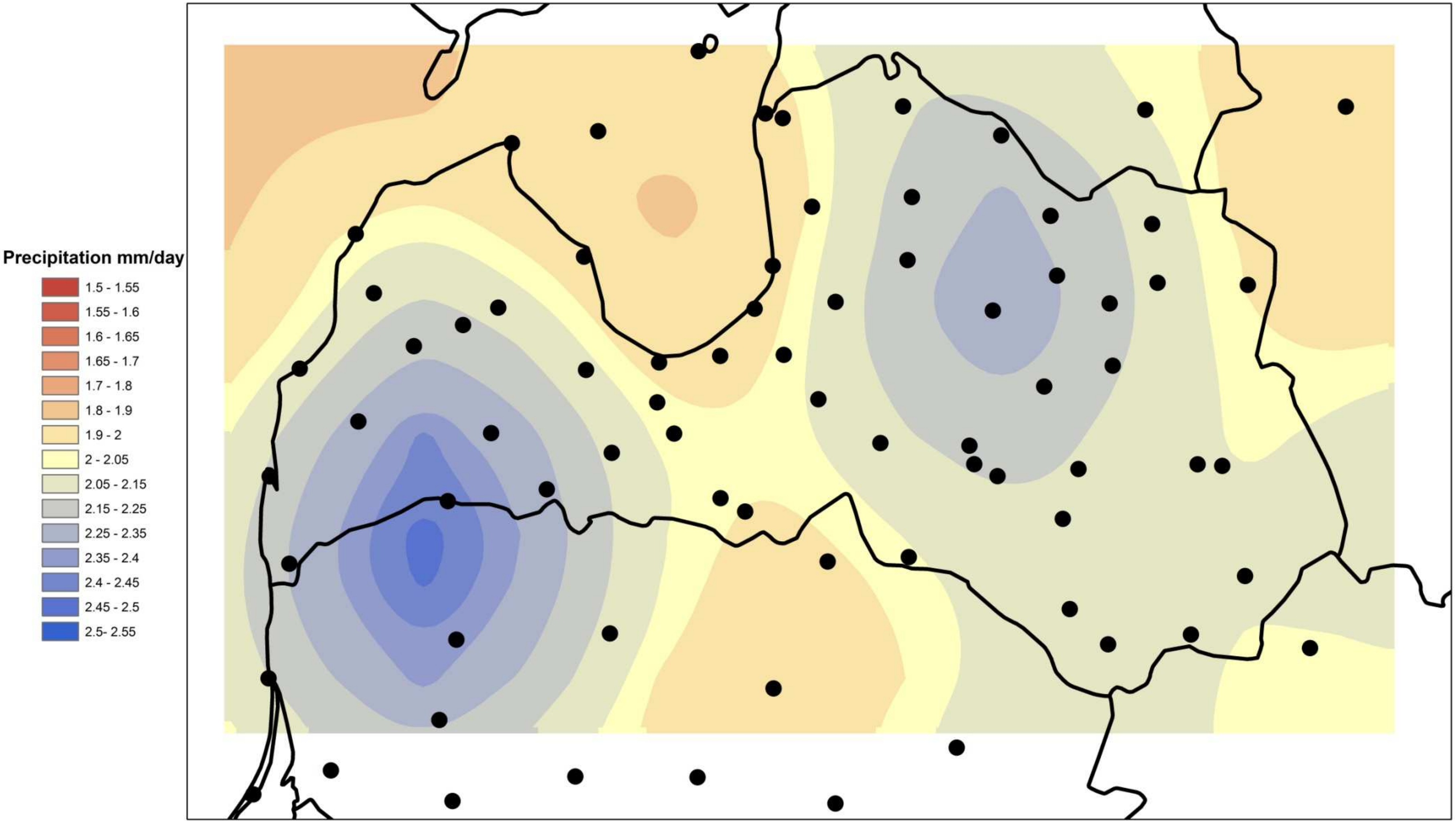


Distribution of yearly average precipitation



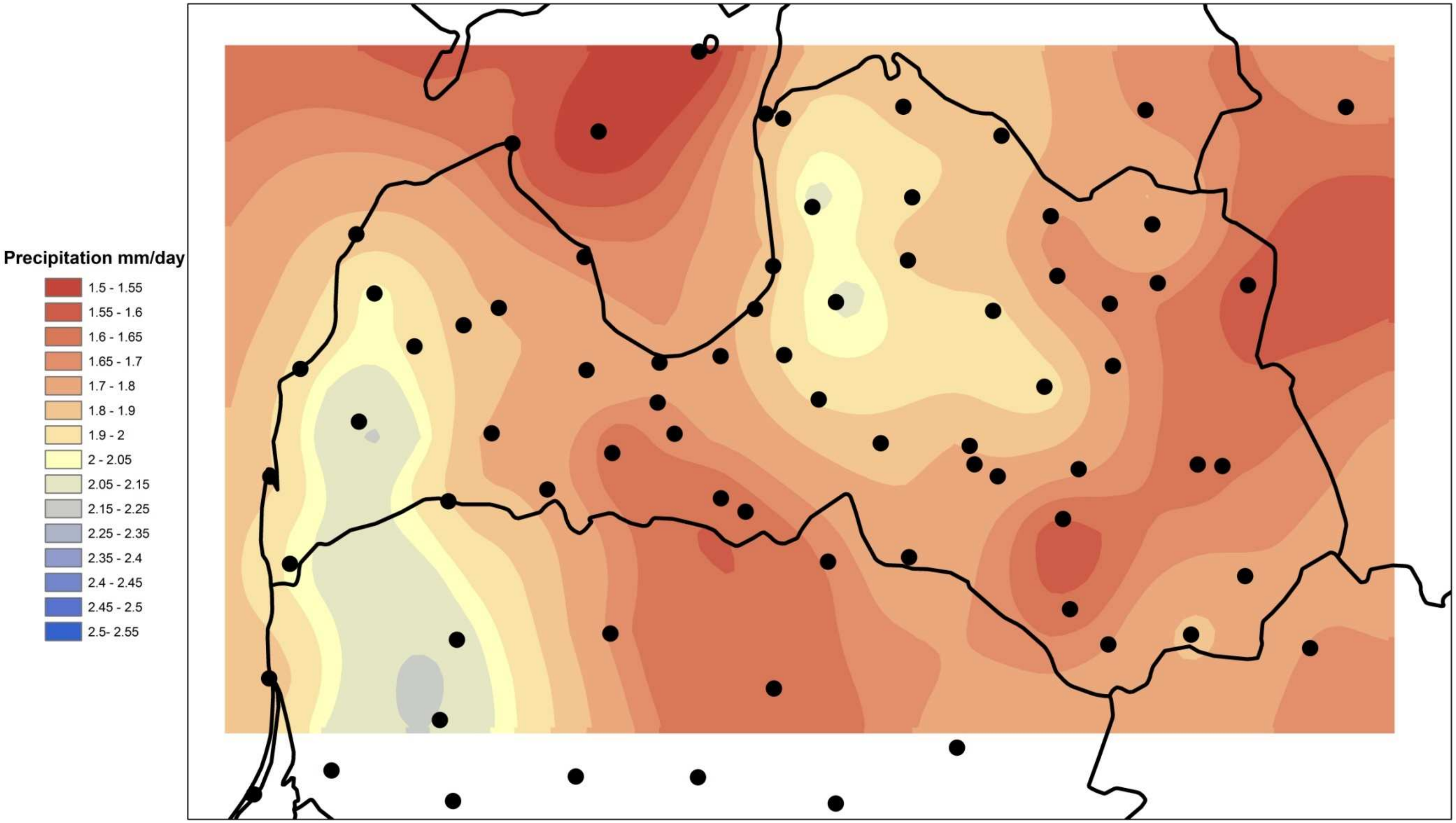
Observed

Distribution of yearly average precipitation



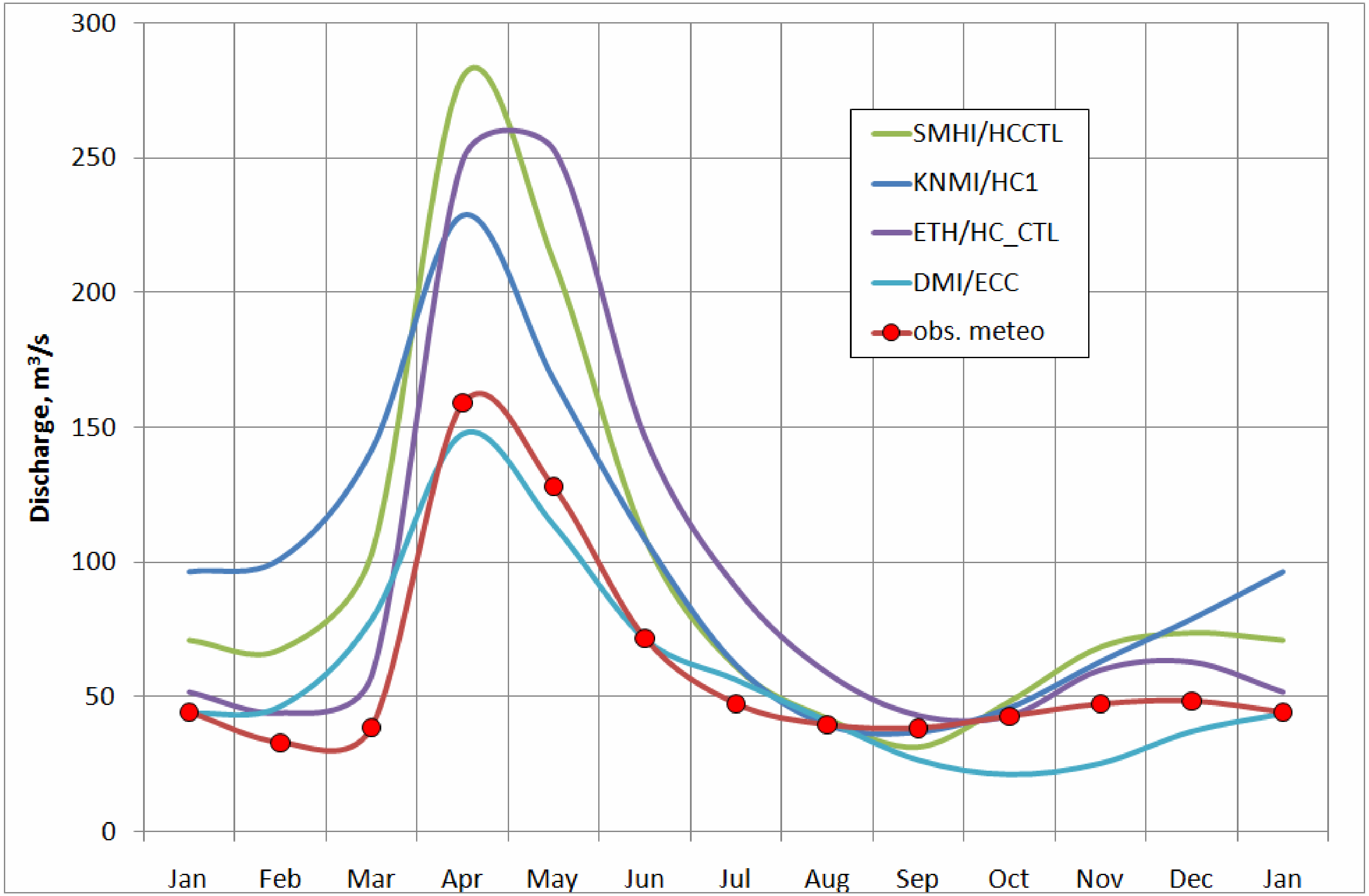
RCM (control period) – SMHI RCAO HCCTL

Distribution of yearly average precipitation



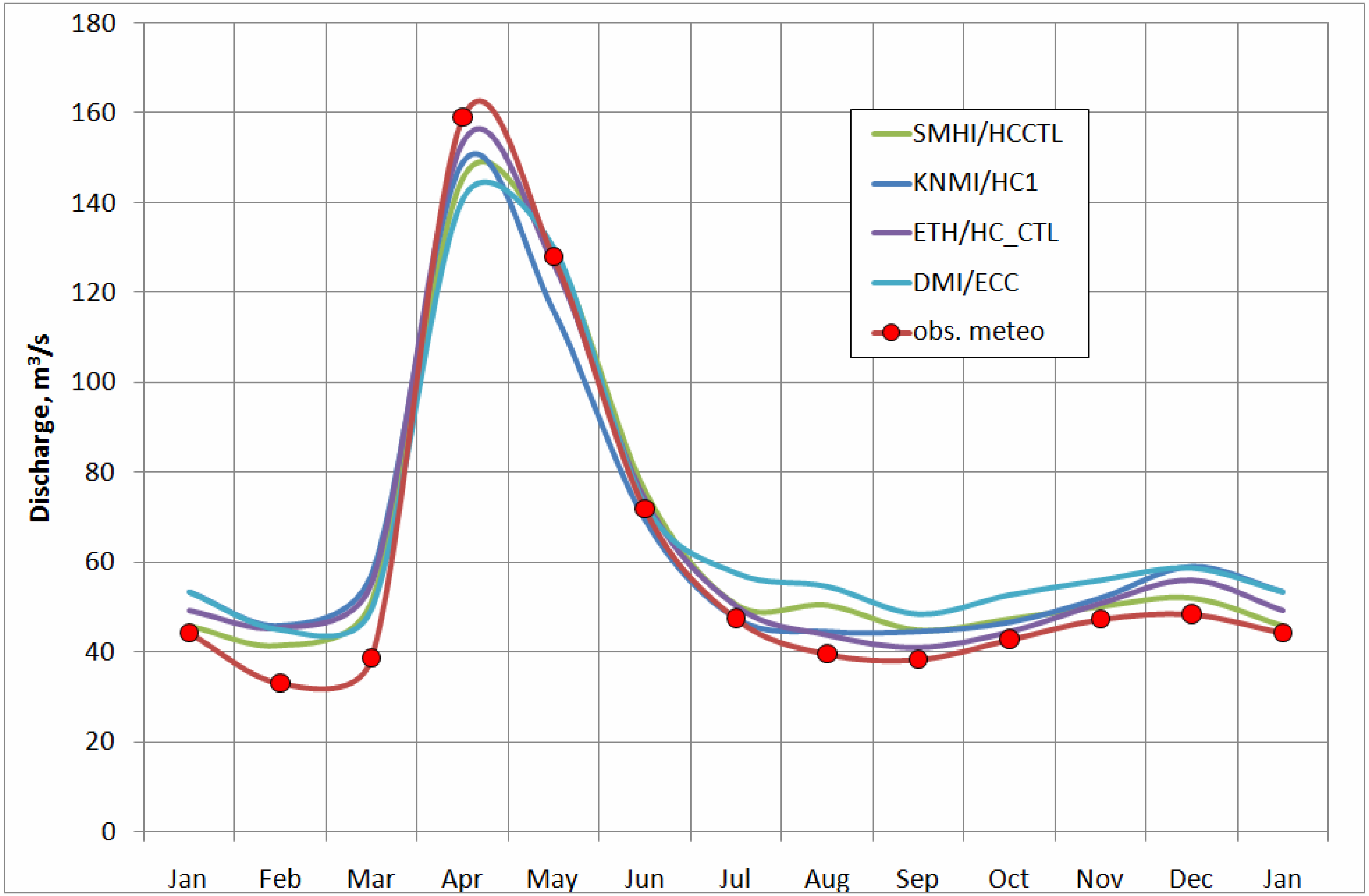
Modified RCM (control period)

Example of hydrological calculation



Calculation with meteorological data from unmodified RCMs

Example of hydrological calculation



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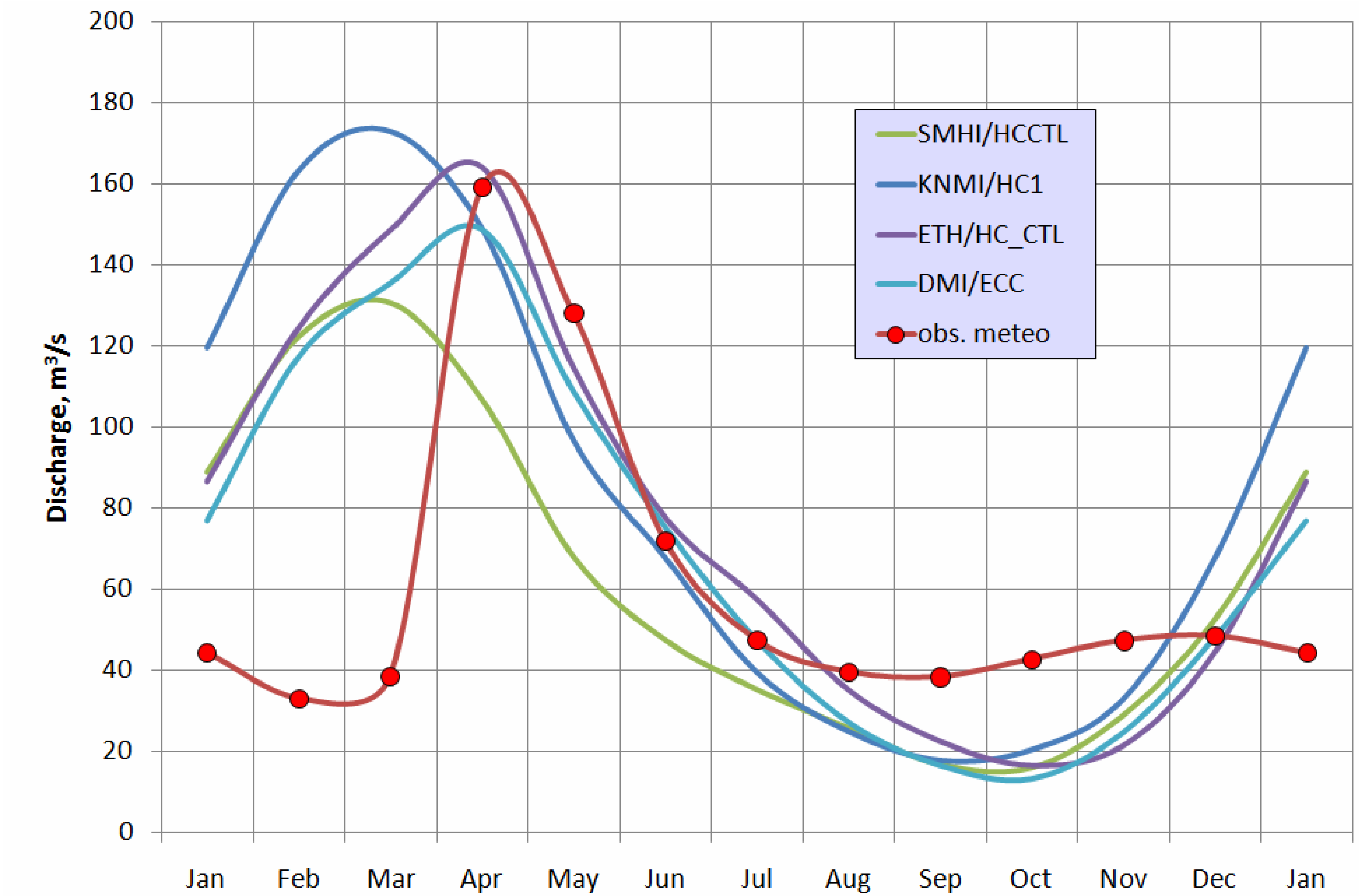
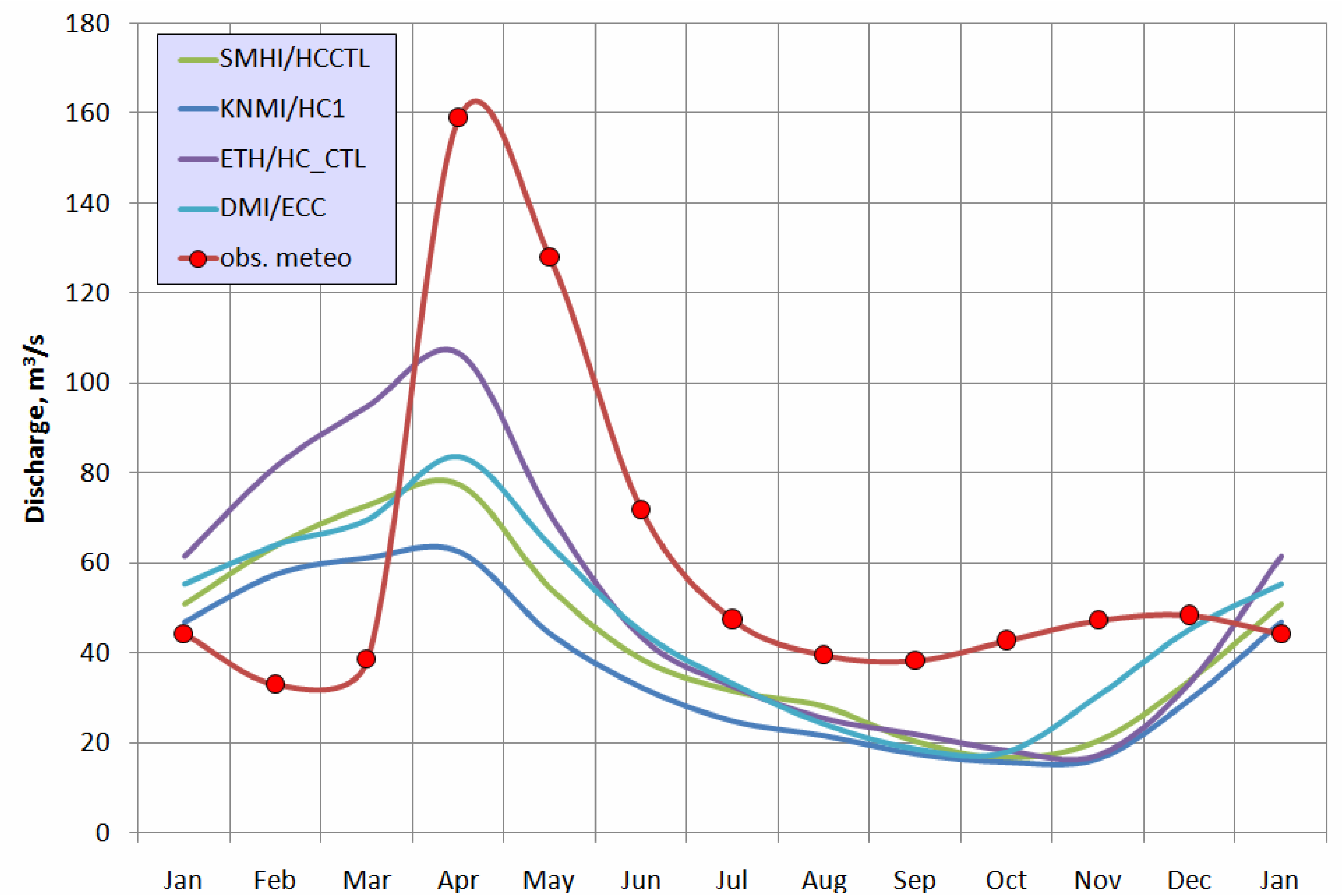
Example of hydrological calculation



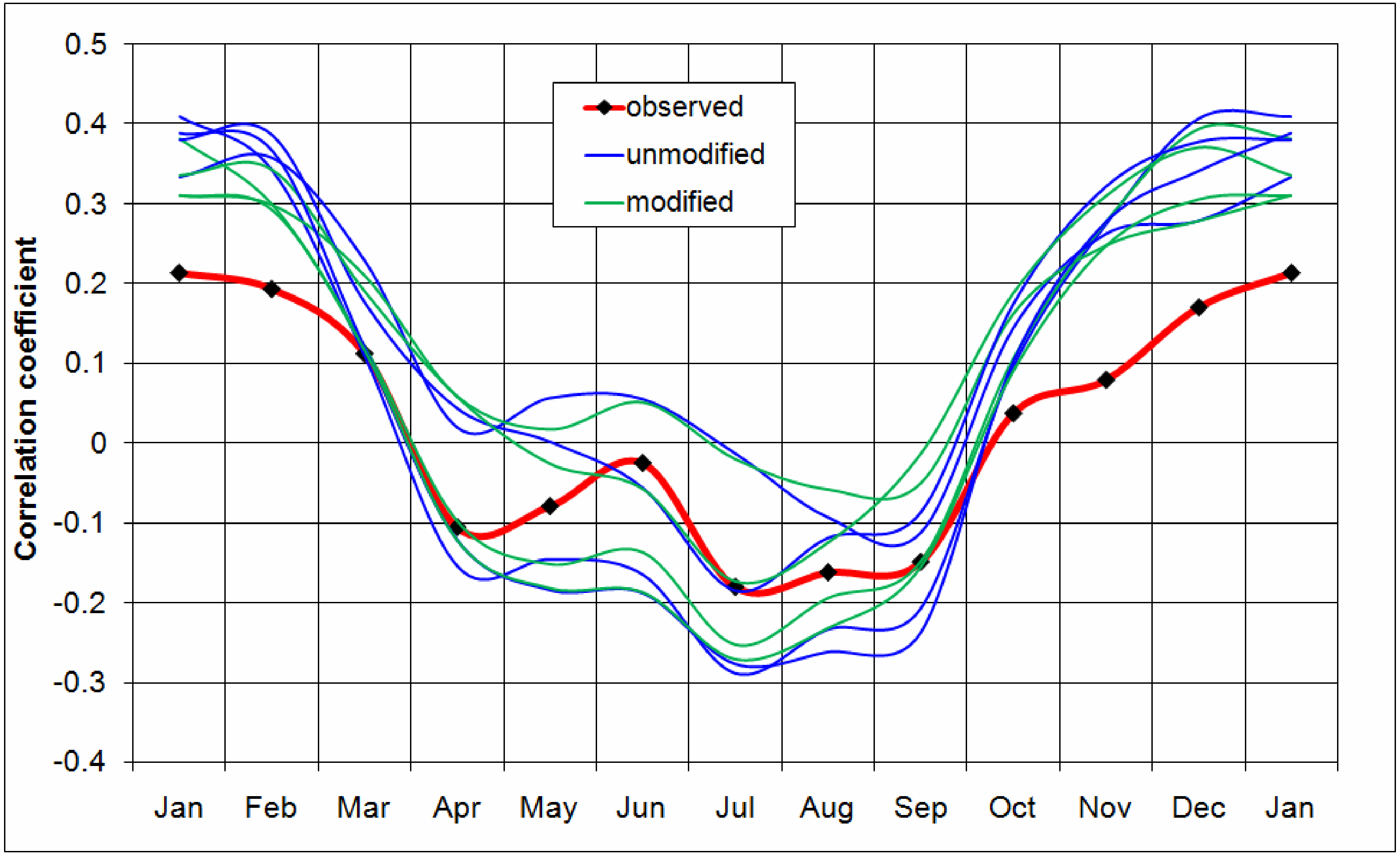
Calculation with meteorological data from unmodified RCMs scenario A2

Example of hydrological calculation



Calculation with meteorological data from modified RCMs scenario A2

T/P correlations



Summary/Conclusions

•The biases in respect to present climate of even the best performing model are too high for direct usage of their output to drive hydrological models.

•The statistical bias correction method with daily cumulative distribution functions can remove biases, modifying the control period data obtained by the RCMs. We show that statistical moments are preserved during this procedure.

•We used dense grid of observational stations to downscale the outputs of RCMs by interpolating differences of observed and calculated CDFs.

•The interannual variability, as well as temperature-precipitation cross-correlation properties cannot be significantly improved by this bias correction as they are inherited from the RCMs.