Bias correction of precipitation with considering spatial structure of precipitation

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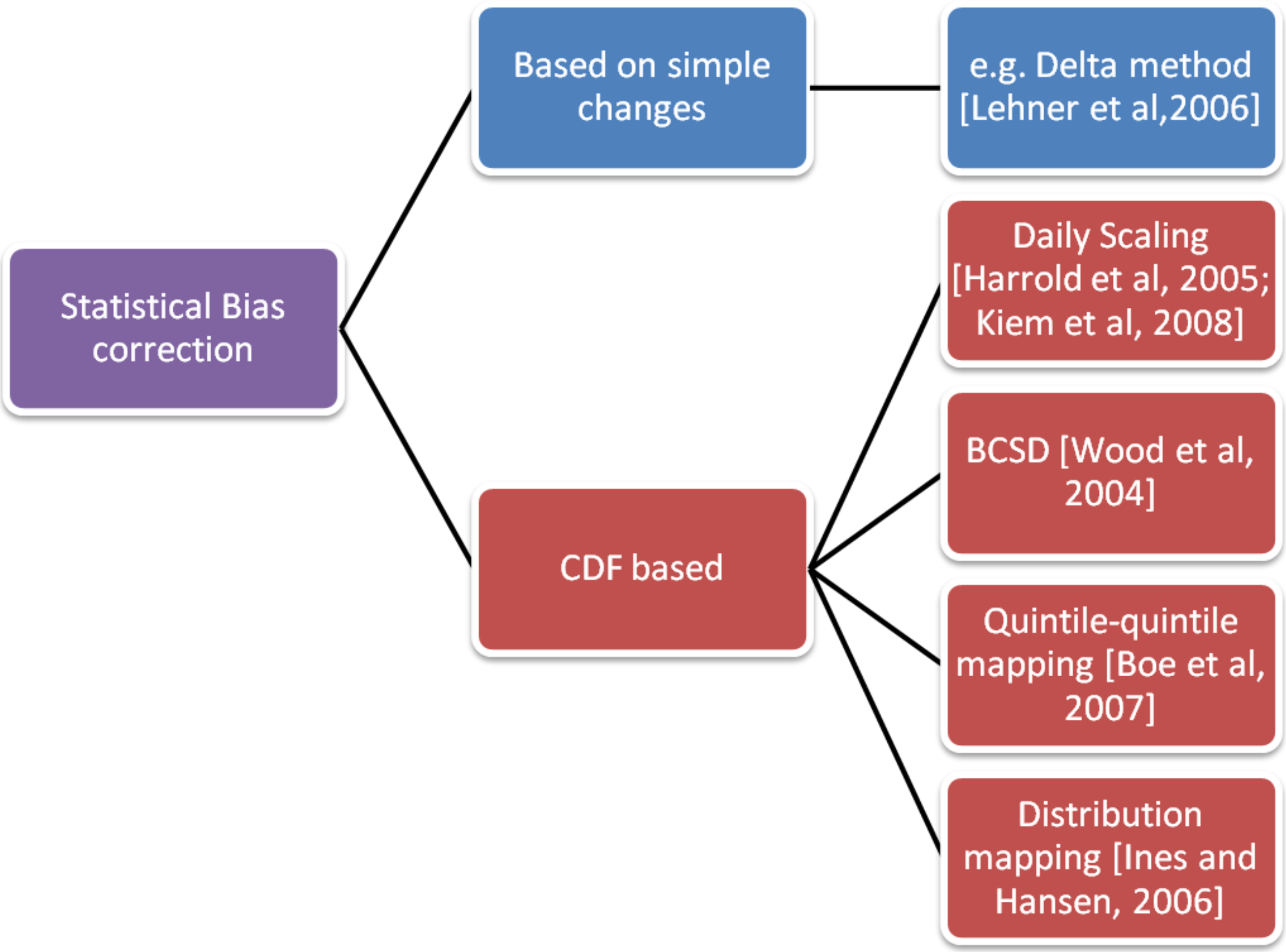
INTRODUCTION

- The output of GCM/RCM has been used for climate impact studies including hydrological impact studies.
- Hydrological simulations in regional scale needs finer and more accurate precipitation data.
- Downscaling or bias correction of GCM/RCM output is necessary
- Several methods for downscaling and bias correction have been proposed.
- This study focuses on bias correction method because the biases of precipitation can largely affect the result of hydrological simulations.

Statistical Bias Correction in literatures



Difference/ratio types

Daily scaling

Non parametric type (monthly)

Non parametric type(daily)

CDF (fitting to distribution)

BIAS CORRECTION METHODS

1) Relative ratio [e.g. Lehner et al, 2006]

Single ratio based on monthly precipitation between observation and model

$$x'_{di} = x_{di}\,\overline{X}_{m,obs} \Big/ \overline{X}_{m,rcm}$$

xdi: ith model precipitation

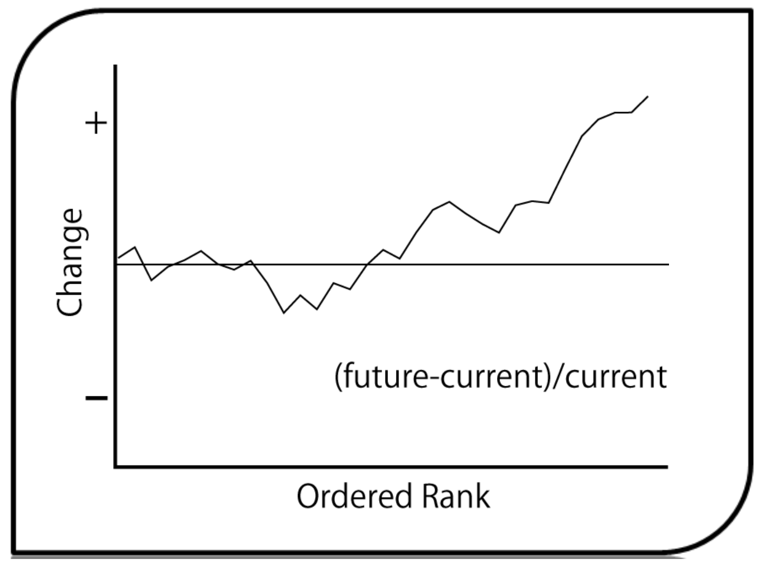
x'di: ith obs. precipitation

Xm,obs: Mon. ave. obs. precipitation

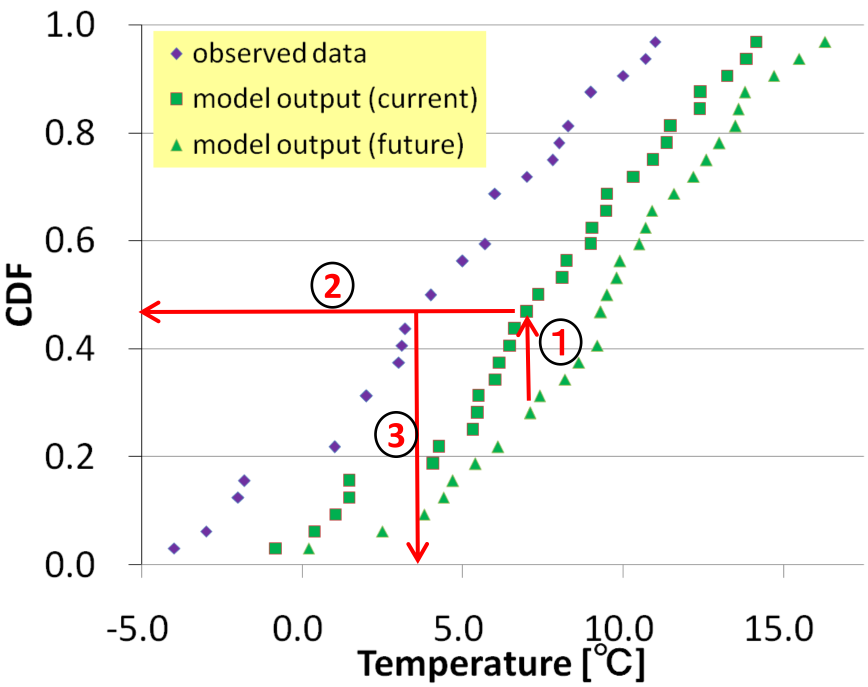
Xm,rcm: Mon. ave. model precipitation

2) Daily Scaling [Kiem et al, 2008]

- Varied ratio across the ordered ranks



3). Cumulative Distribution Function (CDF) based method



Transfer function to make bias corrected model output

$$\tilde{x}_{m-p.adjst.} = F_{o-c}^{-1}(F_{m-c}(x_{m-p}))$$

F_{o-c}: CDF of observations for current period

F_{m-c}: CDF of model for current period

F_{m-p}: CDF of model for future period

x_{m-p}: model output for future period

$X_{m-p.adjst.}$: Bias corrected model output for future period

- These bias correction methods are applied to each grid points independently.
- This could break down the spatial structure of climate model outputs and thus might reduce the reliability of hydrological simulations.
- This study investigates possible ways to conduct bias correction with conserving the spatial structure of model outputs by comparing several bias correction methods.
- The comparison is conducted using the following data.

DATA

Target region： E132-135, N32.5-34.5（Shikoku island in Japan）

Observation: Aphro-JP

– 0.05 × 0.05, daily

– 1981-2000

Climate model: MRI-RCM20

– 20km × 20km grids, daily

– Two 20-years of time period: 1981-2000 (base period), 2031-2050 (future)

	Grid or spatial basis
Ratio	Grid point
Daily Scaling	Grid point
CDF	Grid point
Basin Ratio	Basin mean
Basin Daily Scaling	Basin mean
PCA	Basin mean and PCs

Performance of the bias correction is evaluated by applying 6 bias correction methods for the above data set.

6 bias correction methods are applied, and then

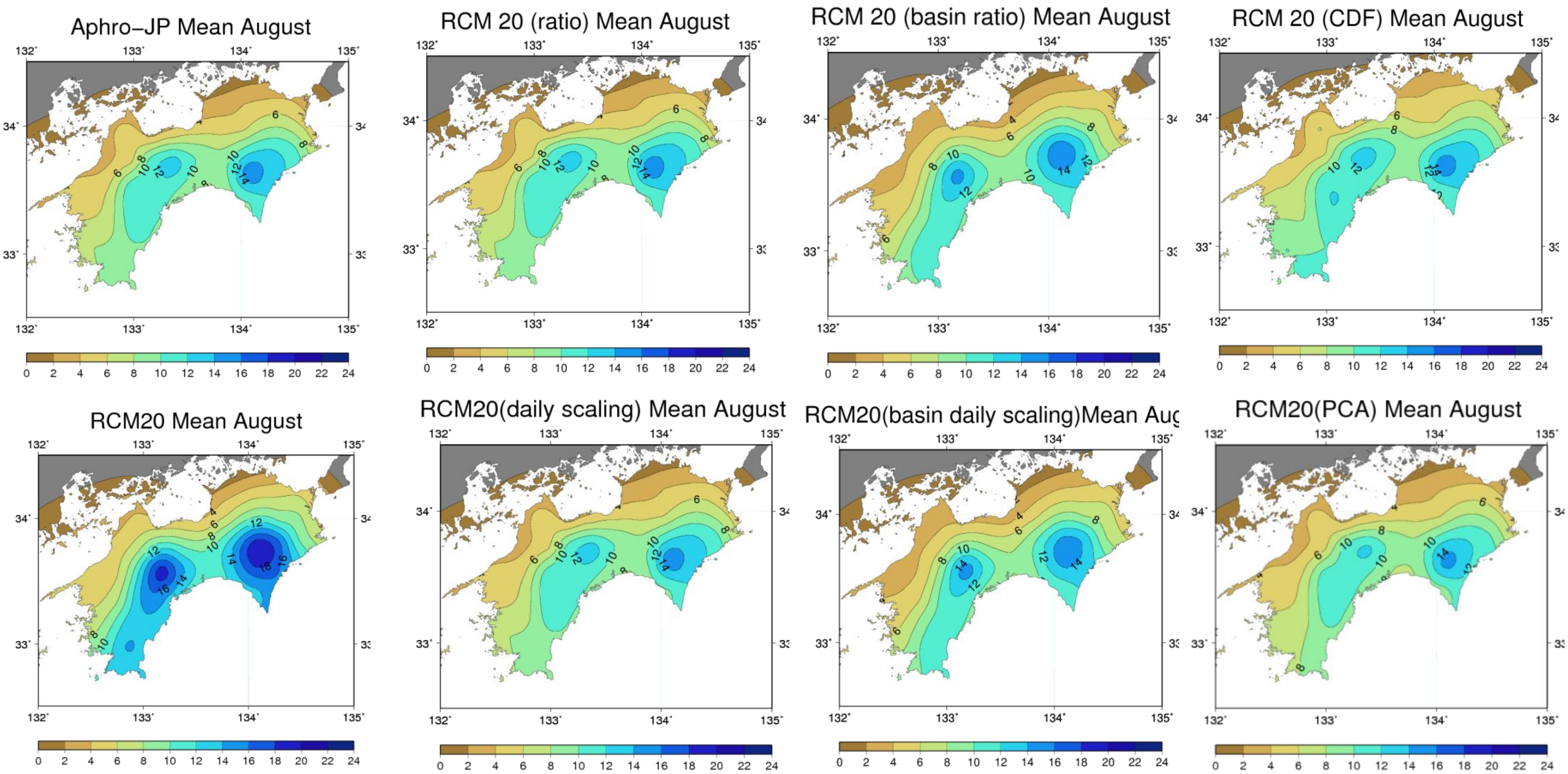
(1) Evaluation of bias corrected products for grid point statistics

Mean, standard deviation for each grid point

(2) Evaluation of bias corrected products for basin average daily precipitation

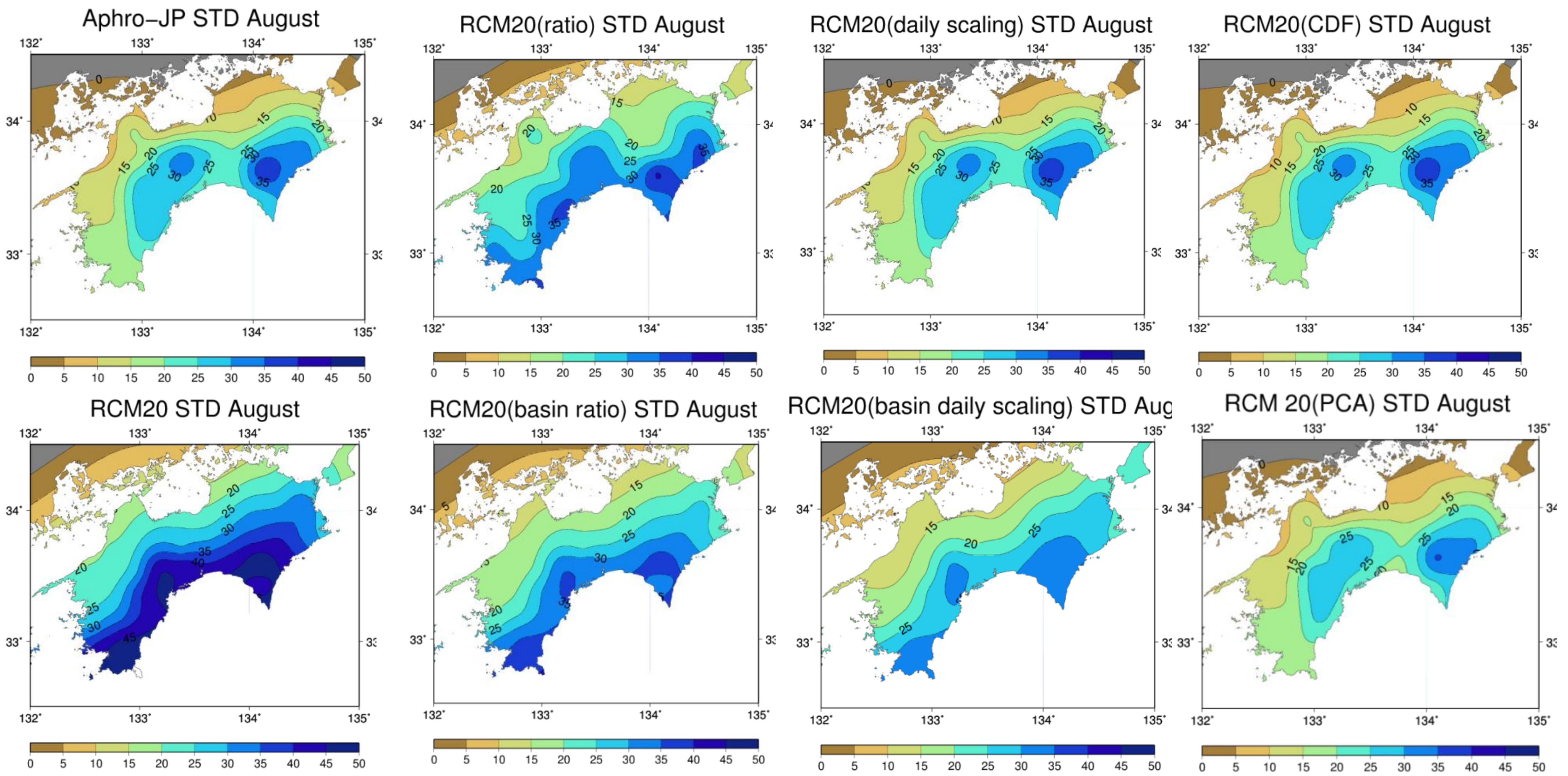
- Comparison of mean and standard deviation (Statistical test for mean and standard deviation for 1981-2000)
- Comparison of CDFs (Cumulative Distribution Function) for basin average daily precipitation for 1981-2000, 2031-2050
- Comparison of extreme values (Computation of maximum daily precipitation for return period of T=10, 30 and 100 years for 1981-2000, 2031-2050)

Grid point mean for observation, RCM20, Ratio, Basin Ratio, Daily scaling, Basin daily scaling, CDF, PCA methods.



- All methods show reasonable performance for daily mean precipitation.
- Basin average approach seems to preserve the spatial structure of model output.

Grid point standard deviation for observation, RCM20, Ratio, Basin Ratio, Daily scaling, Basin daily scaling, CDF, PCA methods.



- Ratio based method does not improve spatial biases of standard deviation.
- Daily scaling, CDF method and PCA method good performance in correcting spatial biases of standard deviation.

Evaluation of bias corrected products for basin average daily precipitation

Basin mean daily precipitation is computed for each of 6 bias corrected products to compare the performance of each method on basin mean precipitation.

- Comparison of shift of distribution an standard deviation

  (Statistical test for shift of mean and standard deviation using data for 1981-2000)
- Comparison of extreme values

  (Estimation of maximum daily precipitation for return period of T=10, 30 and 100 years for 1981-2000, 2031-2050)
- Comparison of CDFs for 1981-2000, 2031-2050

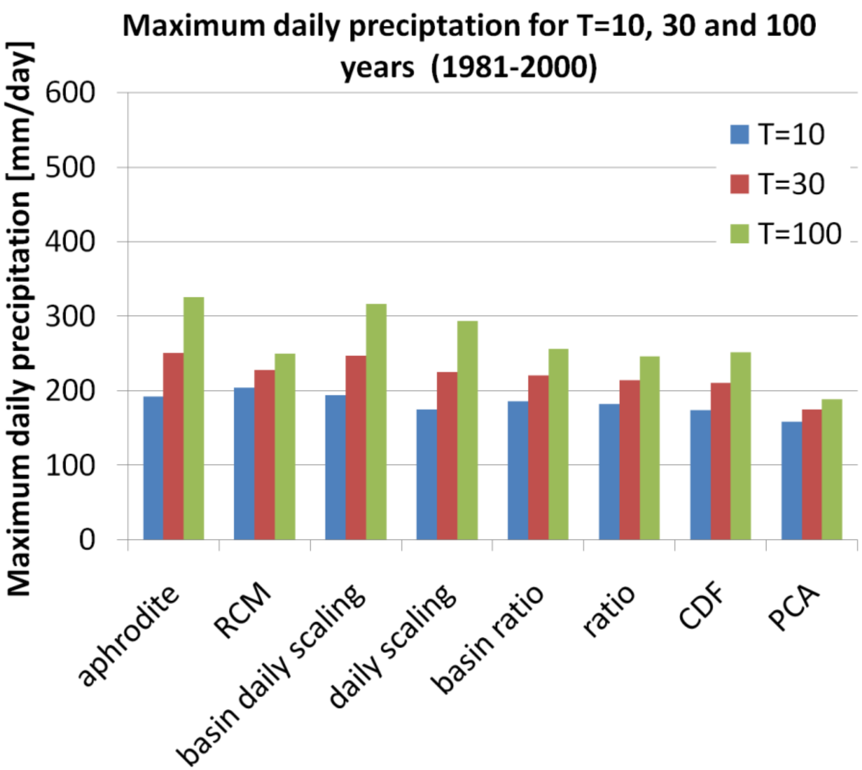
Evaluation for basin mean daily precipitation

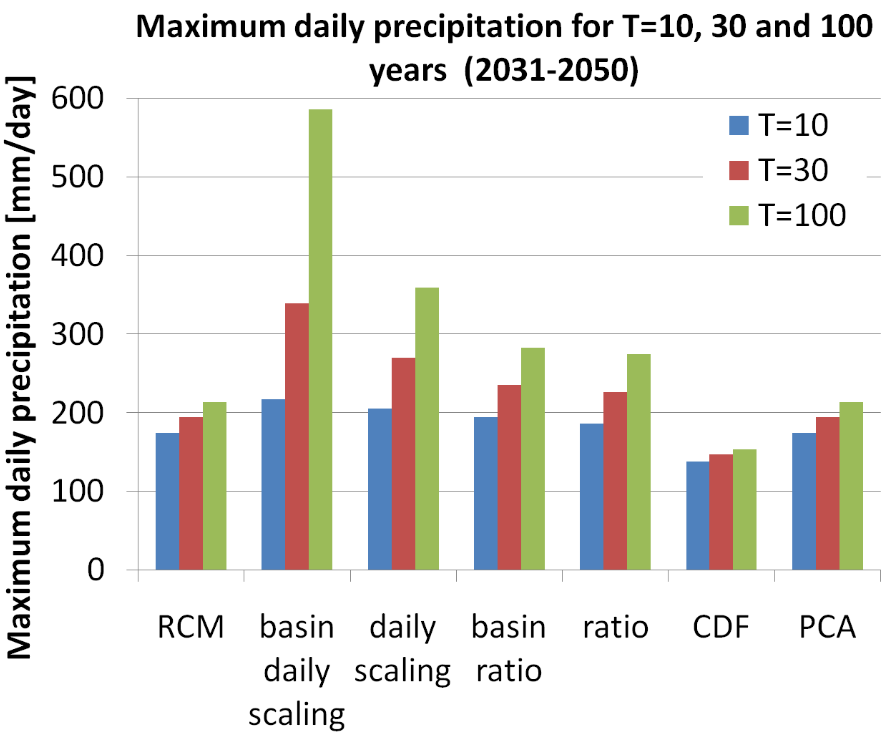
Test for shift of distribution and standard deviation　basin mean daily precipitation

	MW test	Leven'test
RCM	0.00000	0.01953
ratio	0.00000	0.29993
basin ratio	0.00000	0.33326
daily scaling	0.00000	0.58137
basin daily scaling	0.97830	0.99999
CDF	0.00000	0.53603
PCA	0.54971	0.66345

MW: Mann-Whitney test (test for shift of distribution against observation)
Leven’s test (test for equal variance against observation)

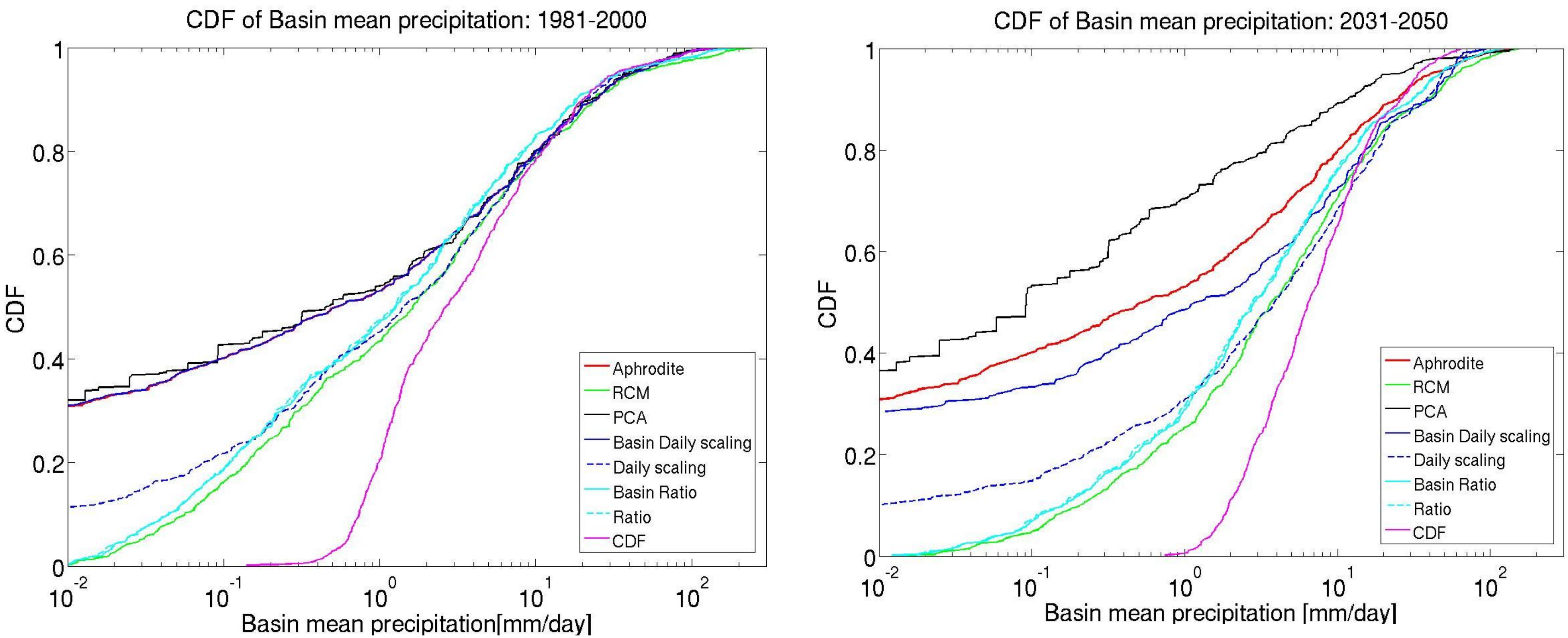
Estimation of annual maximum daily precipitation using GEV (Generalized Extreme Value distribution) for T=10, 30 and 100 against 1981-2000 and 2031-2050, respectively





- For present and future, basin daily scaling method tend to show large variation for different return period.
- PCA method show low estimation of maximum daily precipitation.
- Discrepancy among different methods seems to be larger in future period.

CDFs (Cumulative Distribution Function) against 1981-2000 and 2031-2050, respectively for 6 bias correction methods



- The basin daily scaling and PCA method showed quite similar CDF against observation.
- For future projection period, the discrepancies of CDF among different bias correction method are remarkable.

SUMMARY

- Basin mean daily precipitation of basin daily scaling and PCA based method shows similar CDF to observation.
- Daily scaling method shows large variation of extreme values for both present and future period.
- The discrepancy of distribution among different bias correction methods seems to become large in future period.
- Extreme value is sensitive to choice of bias correction methods.
- Different bias correction methods produces different distribution of bias corrected products