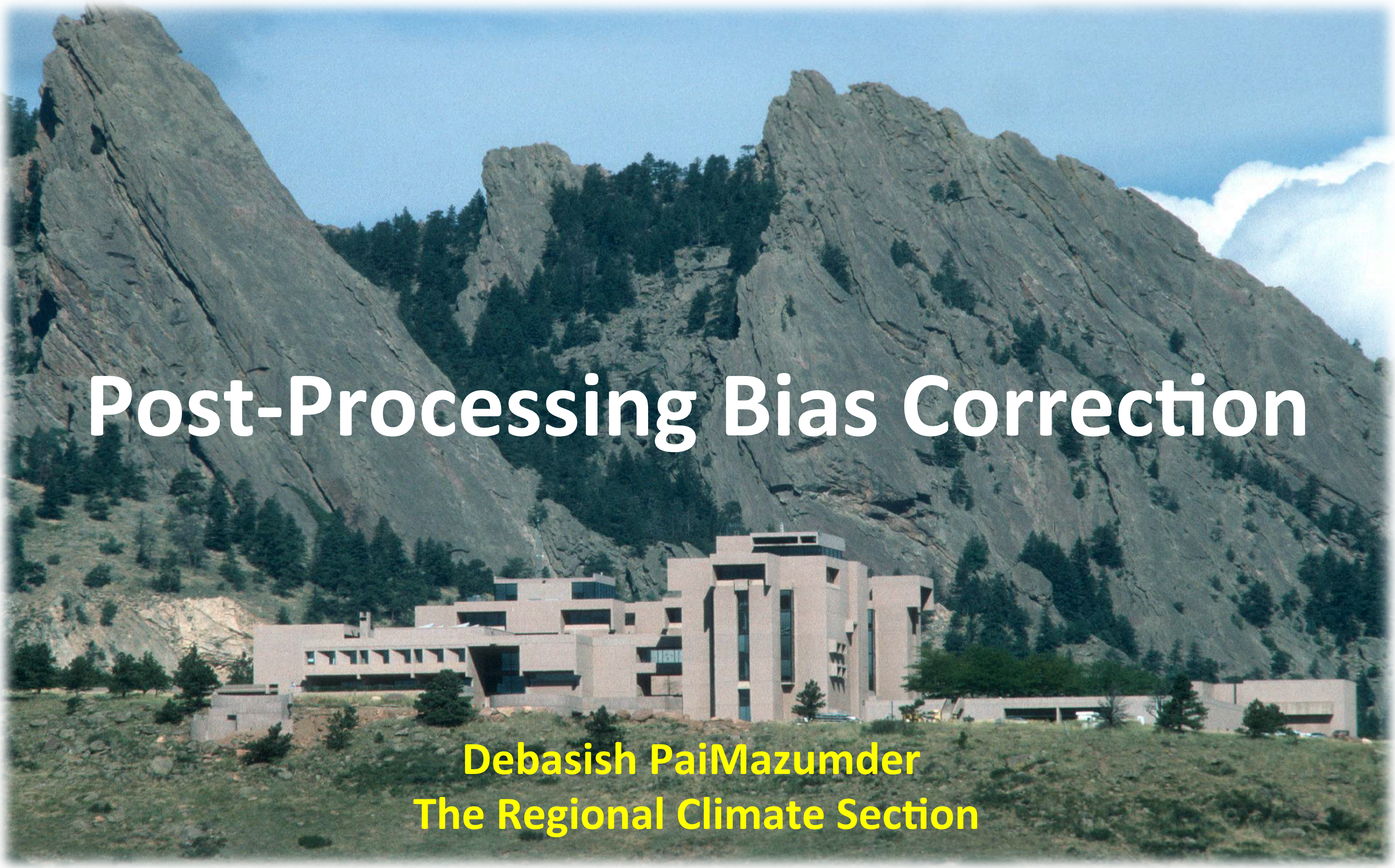
NCAR Earth System Laboratory
National Center for Atmospheric Research



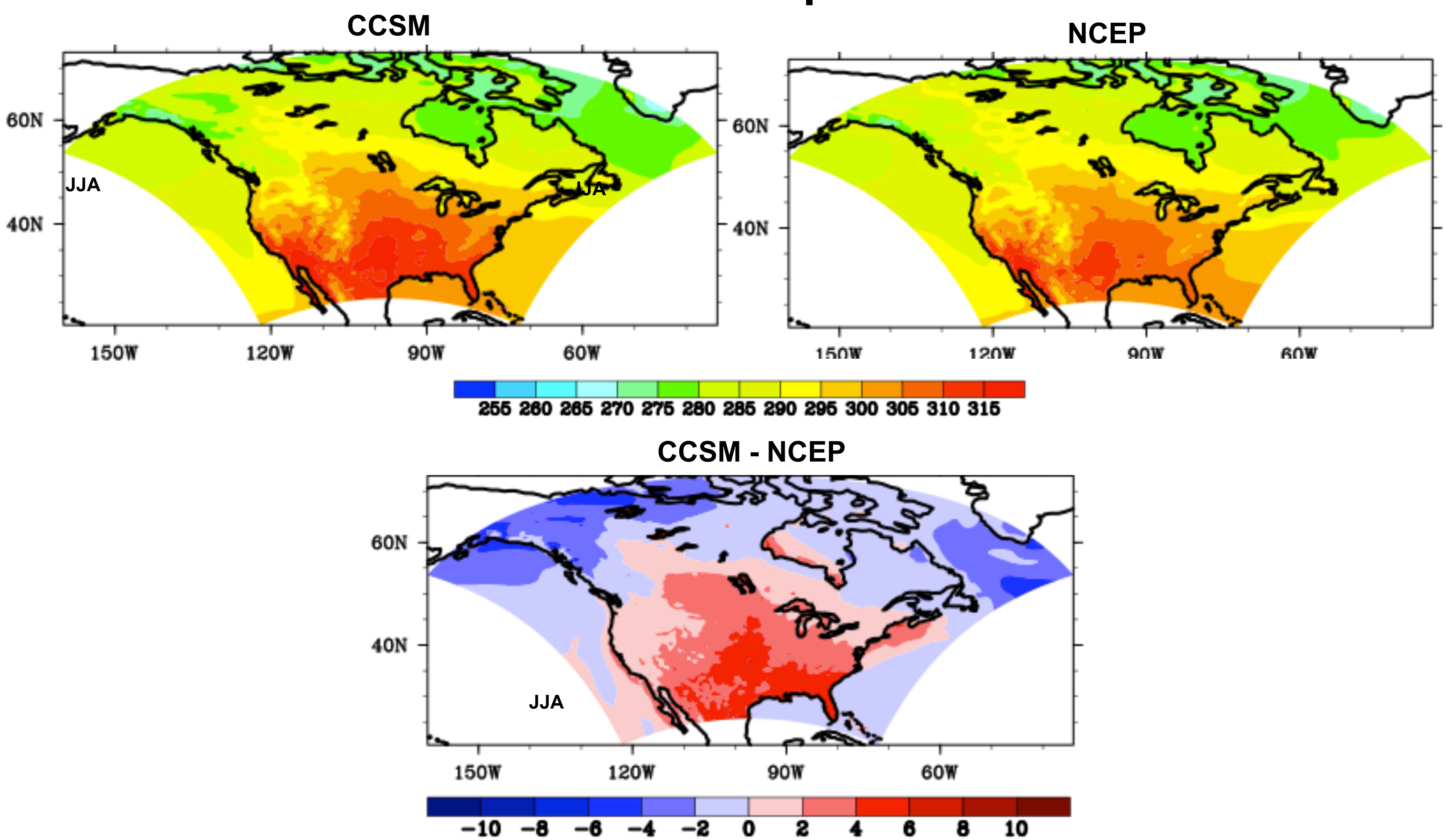
Post-Processing Bias Correction

Debasish PaiMazumder
The Regional Climate Section

Motivation of boundary bias correction

Canadian Regional Climate Model (CRCM)

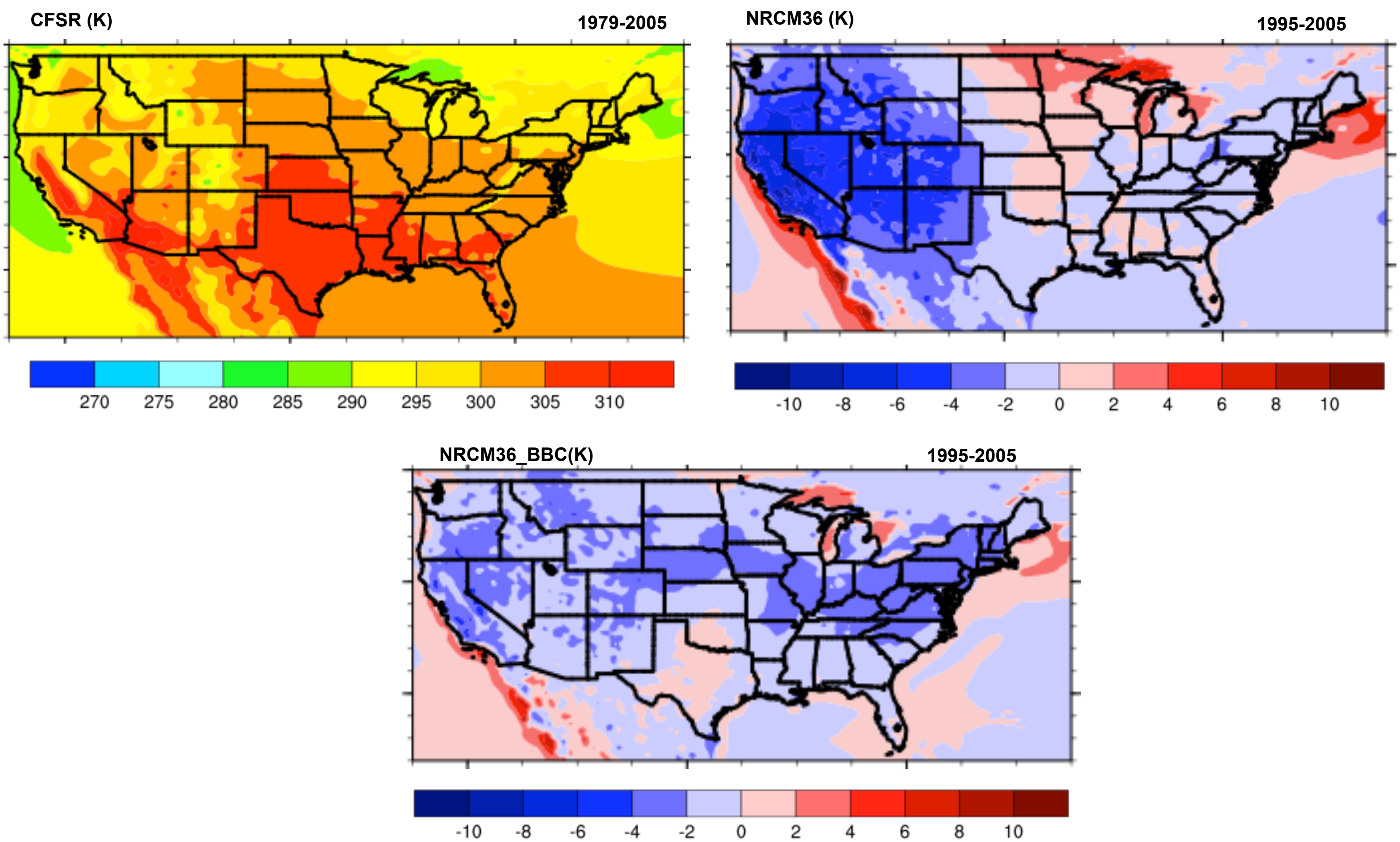
Maximum Temperature



Biases coming from CCSM3 motivates bias correction of the driving data.

Motivation of post-processing bias correction

Maximum Temperature



The difference between NRCM36 and NRCM36_BBC motivates the need for post processing bias correction.

Bias correction methods

- Systematic bias correction (correcting mean)
- Delta approach
- Transfer function
- Multiple linear regression
- Analogue methods
- Q-Q mapping
- Local intensity scaling
- MOS

Systematic Bias Correction

❑ For Temperature

Monthly bias:

$$BC_m = \overline{Ts_m} - \overline{To_m}$$

where m = 1,2,…,12 months, Ts and To simulated and observed temperature

Corrected temperature:

$$Tc_t = Ts_t - BC_m$$

where t = 6hourly/daily timestep

❑ For Precipitation

Monthly ratio:

$$R_m = \overline{Po_m} \,/\, \overline{Ps_m}$$

where m = 1,2,…,12 months, Ps and Po simulated and observed precipitation

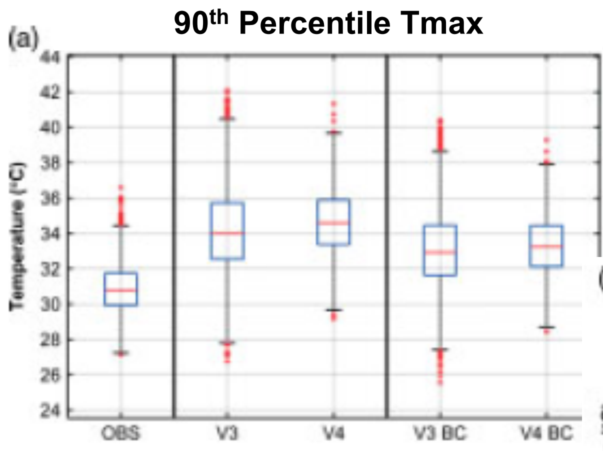
Corrected precipitation:

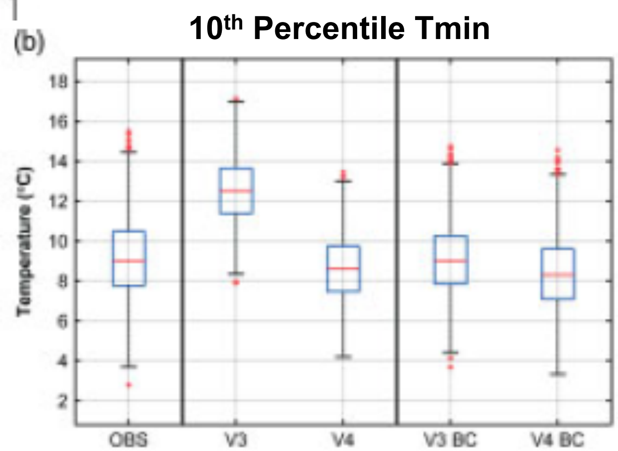
$$Pc_t = Ps_t * R_m$$

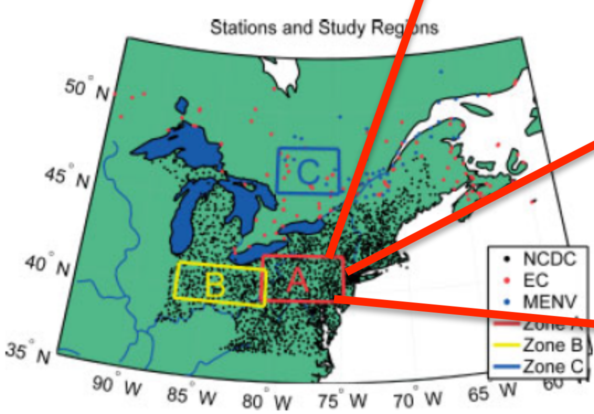
where t = 6hourly/daily timestep

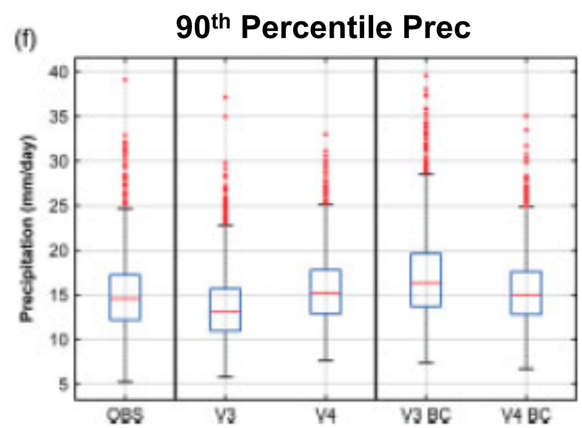
Application of systematic bias correction

V3: CRCM 3.7.1
V4: CRCM 4.1.1









A: Pennsylvania,
B: Ohio and parts of Indiana
C: south-eastern Ontario and south-western Quebec

Roy et al. 2011

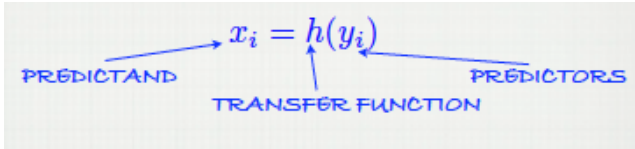
Change Factor (Delta method)

- Take change factor between control and future simulations of GCM or RCM and apply to observed climate series (e.g. monthly rainfall totals)
- For temperature, change factor : $\overline{T}_{GCM:future} - \overline{T}_{GCM:reference}$ is added to reference climatology
- For precipitation, change factor: $(\overline{P}_{GCM:future} - \overline{P}_{GCM:reference}) / \overline{P}_{GCM:reference}$ is multiplied to reference climatology

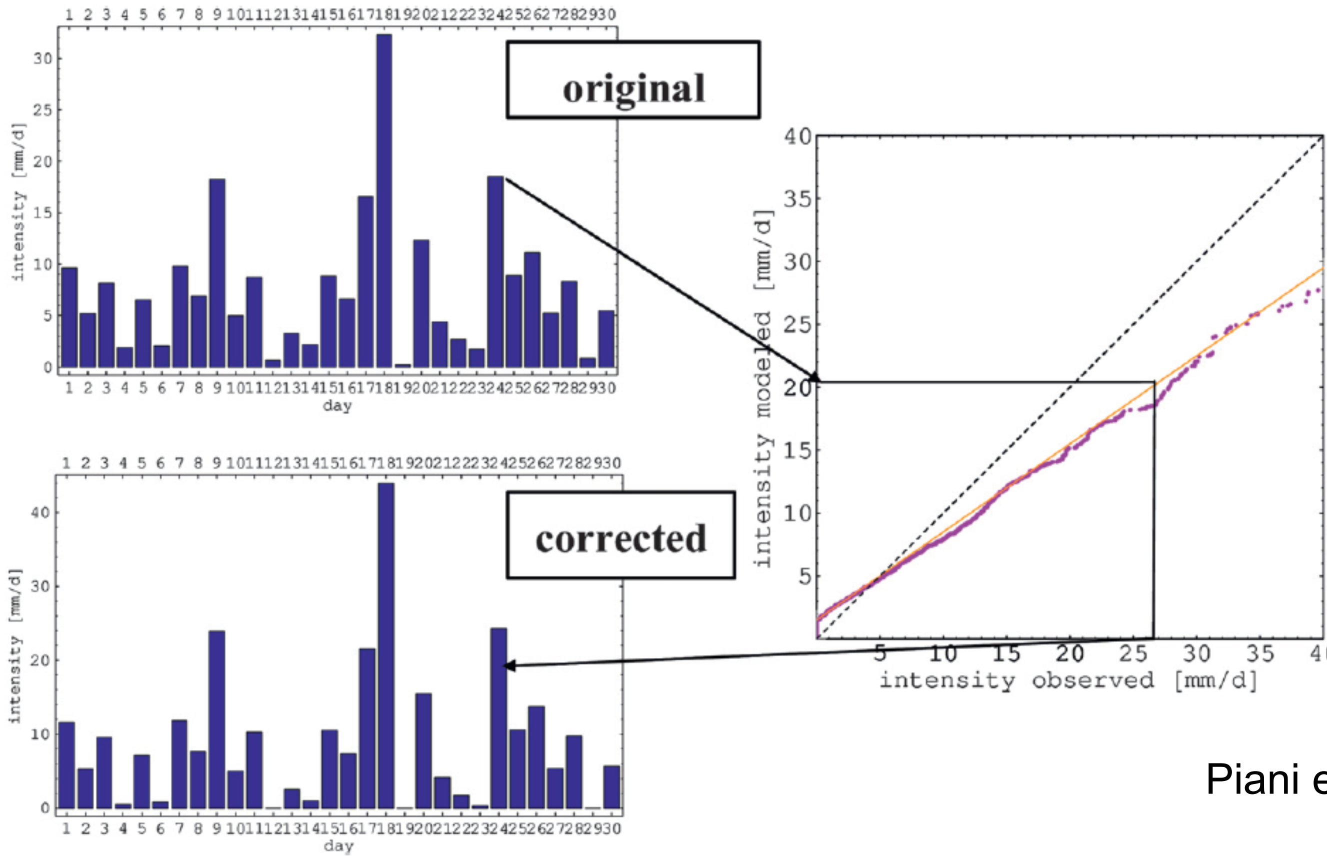
Limitation

- Range and variability remain unchanged
- Spatial pattern of present climate remains unchanged
- For precipitation : affect the number of rain days and the size of extreme events
- Temporal sequencing is unchanged: do not account for changes in wet-/dry-spell lengths
- Choice of GCM grid-box (drift issue)

Transfer function method



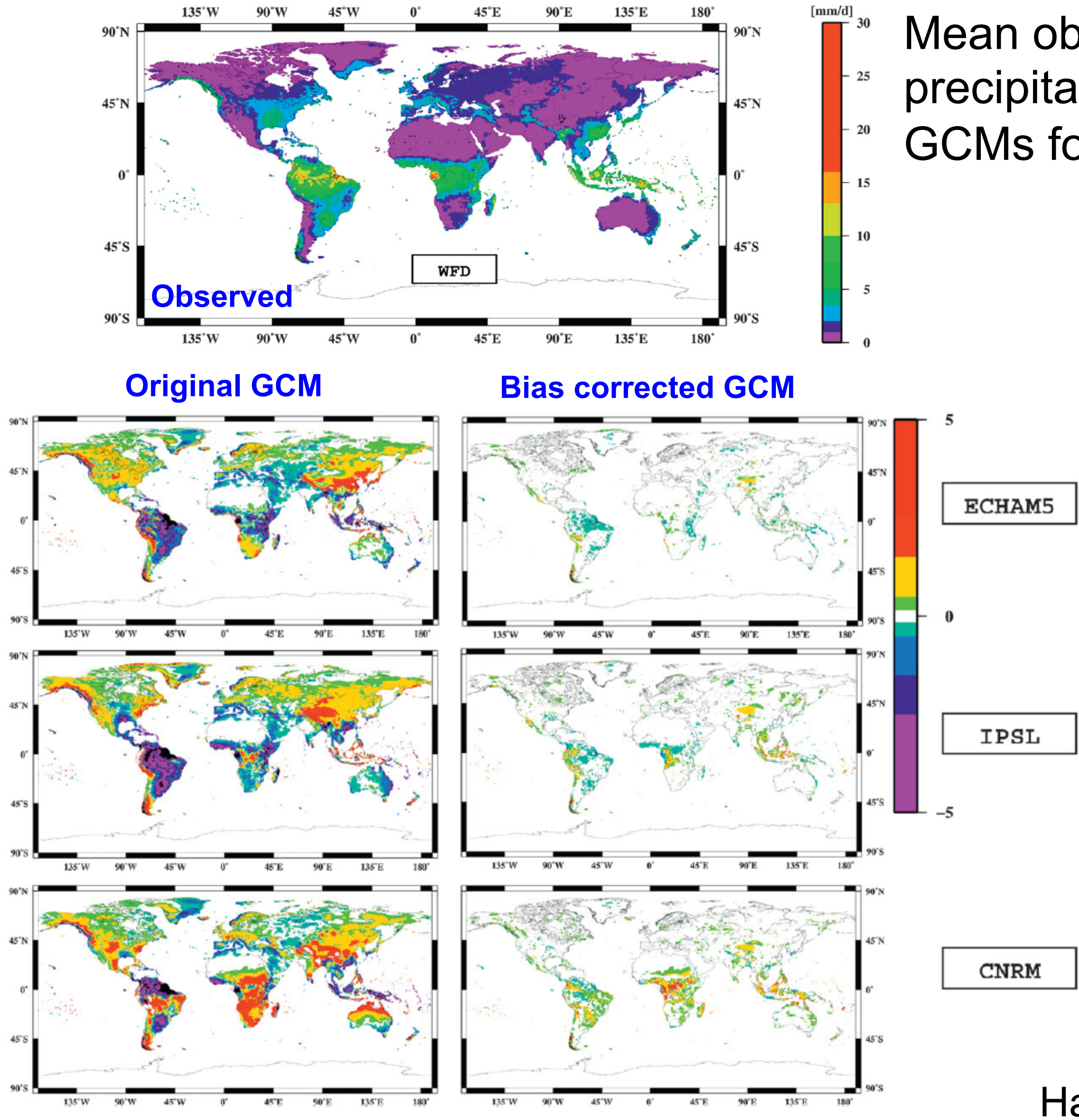
Transfer function is time independent, thus applicable to future



Piani et al. 2010

Example for correcting original model data using a transfer function obtained from cumulative distribution functions of observed and modeled intensities

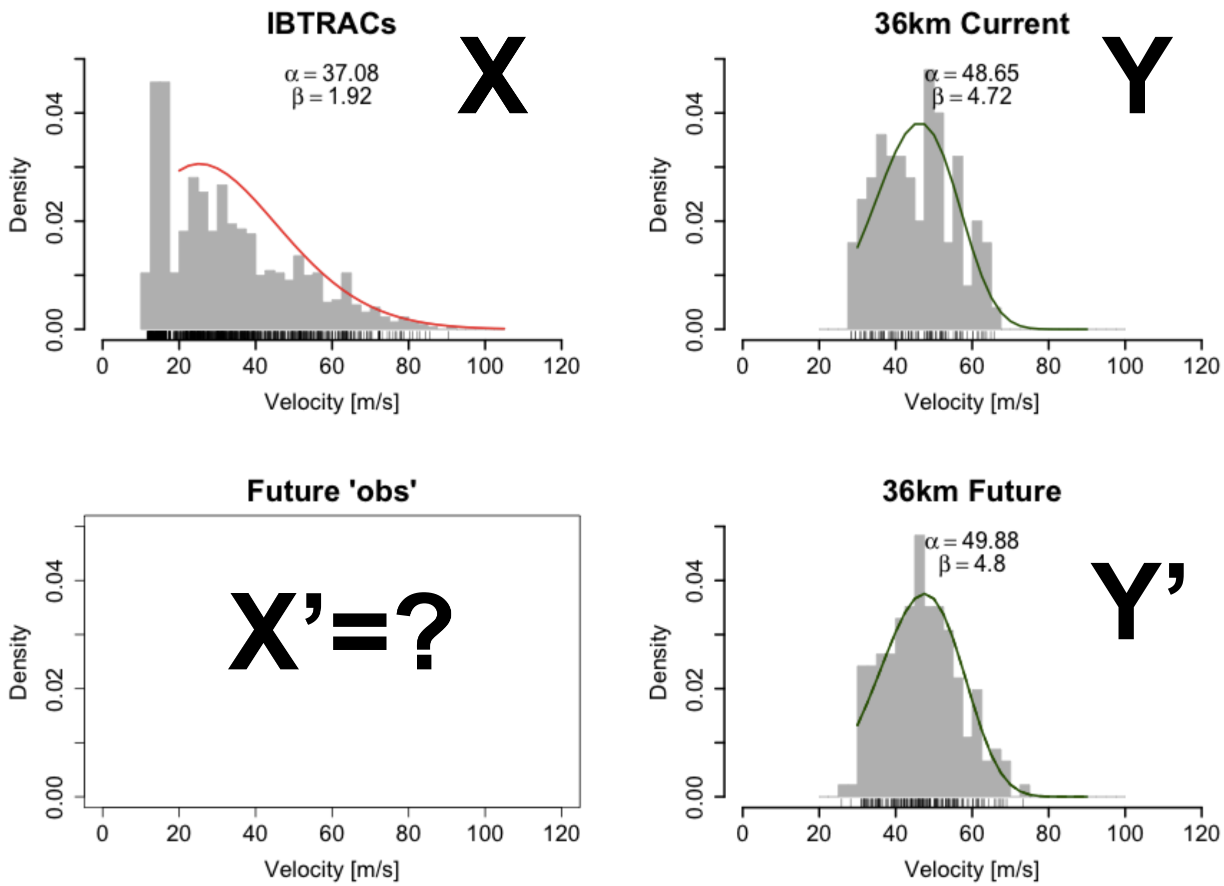
Application of Transfer function method



Mean observed precipitation and bias of GCMs for April, 1960-1999

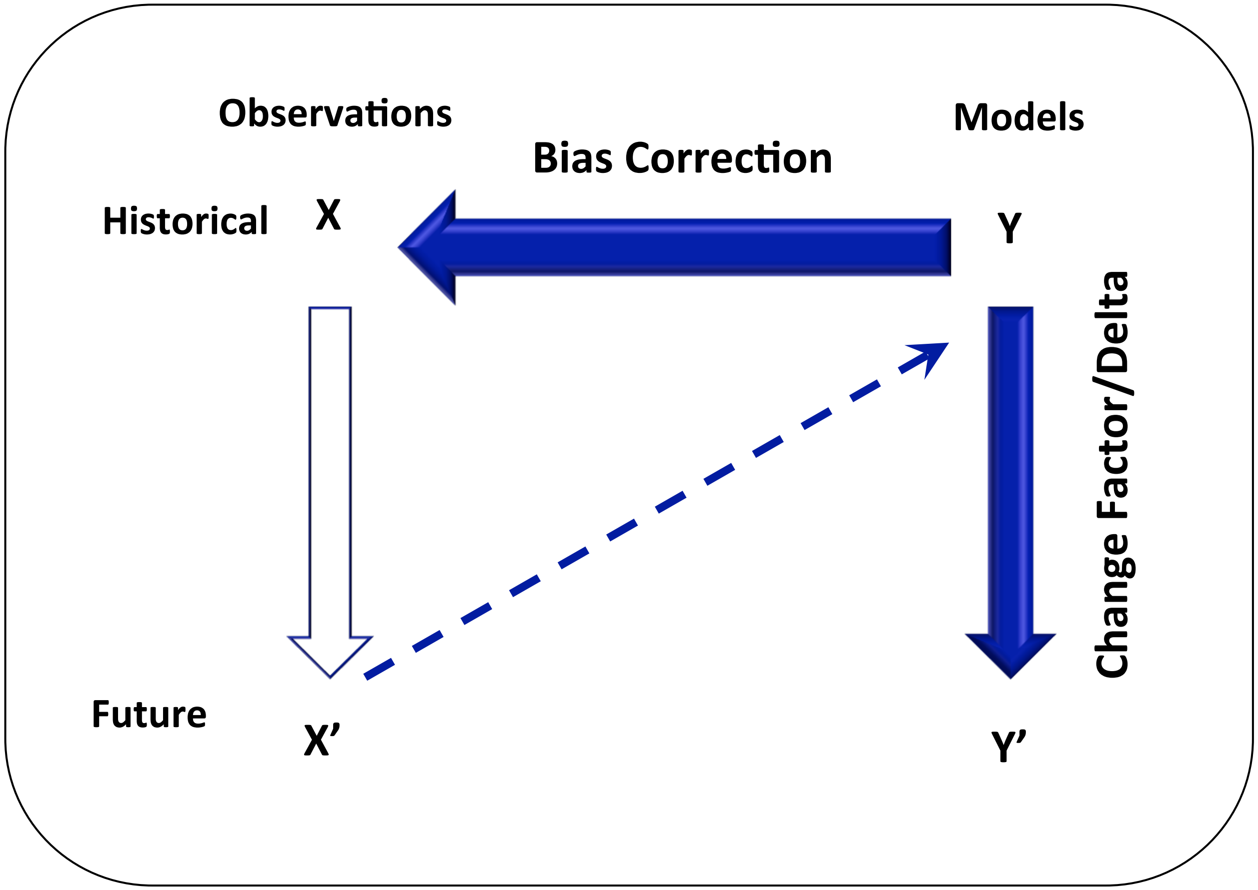
Hagemann et al. 2011

Wind speeds & superimposed best Weibull fits



- ❑ Very different distributions for model simulations than observed
- ❑ Weibull distributions provide good fits to all high wind speeds

Two approaches to transform model output



- ❑ Apply differences between control model and observations to get future
- ❑ Weibull distributions provide good fits to all high wind speeds

Use fitted distributions

- Fit appropriate statistical distribution (e.g. Weibull)
- Transform parameters for future estimates
- Obtain “observed future” distribution

Parameter Transformations

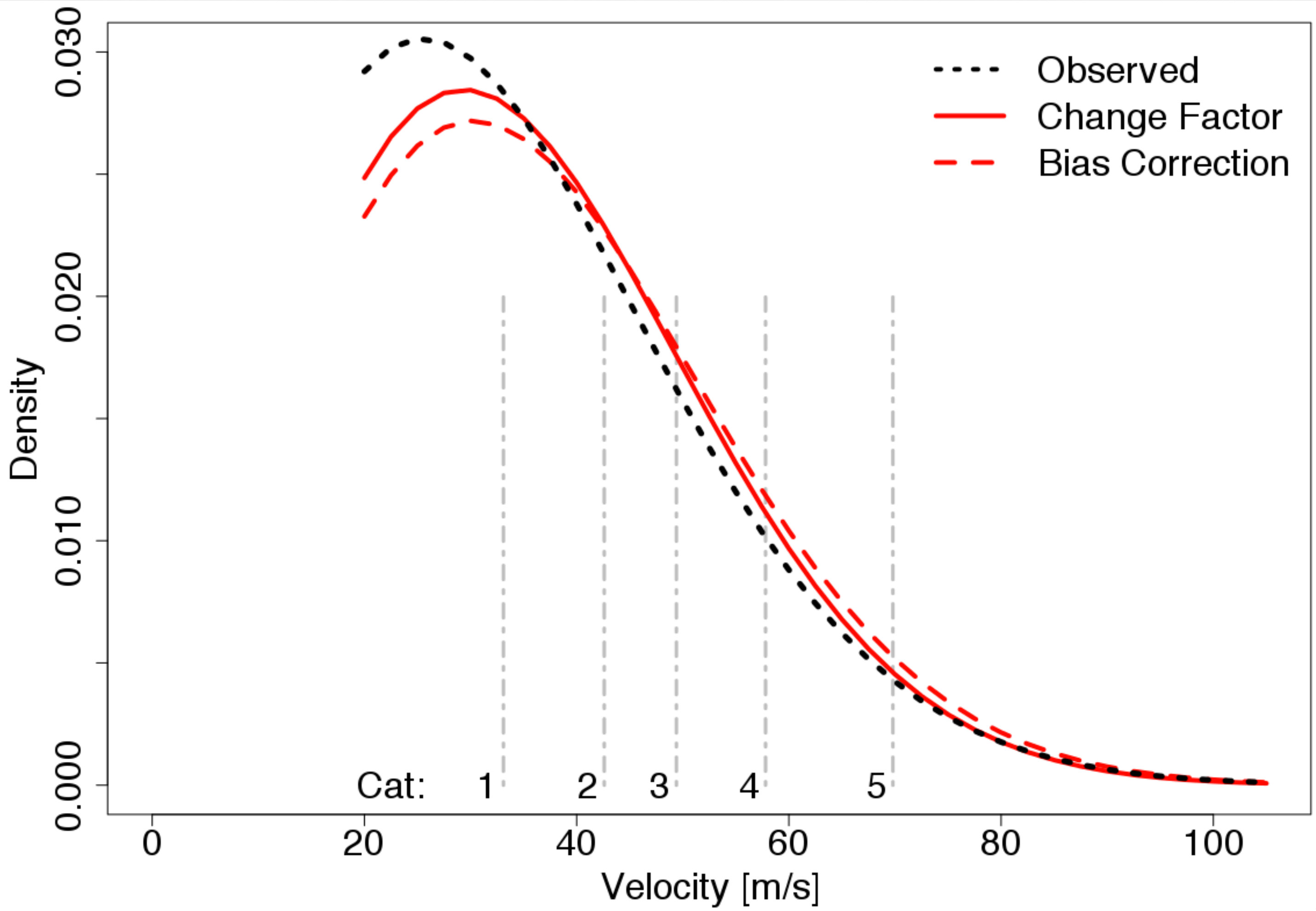
Shape: $$\beta_{X'} = \frac{\beta_X \beta_{Y'}}{\beta_Y}$$

Scale (CF): $$\alpha_{X'} = \alpha_{Y'} \left(\frac{\alpha_X}{\alpha_Y} \right)^{\beta_Y / \beta_{Y'}}$$

Scale (BC): $$\alpha_{X'} = \alpha_X \left(\frac{\alpha_{Y'}}{\alpha_Y} \right)^{\beta_Y / \beta_X}$$

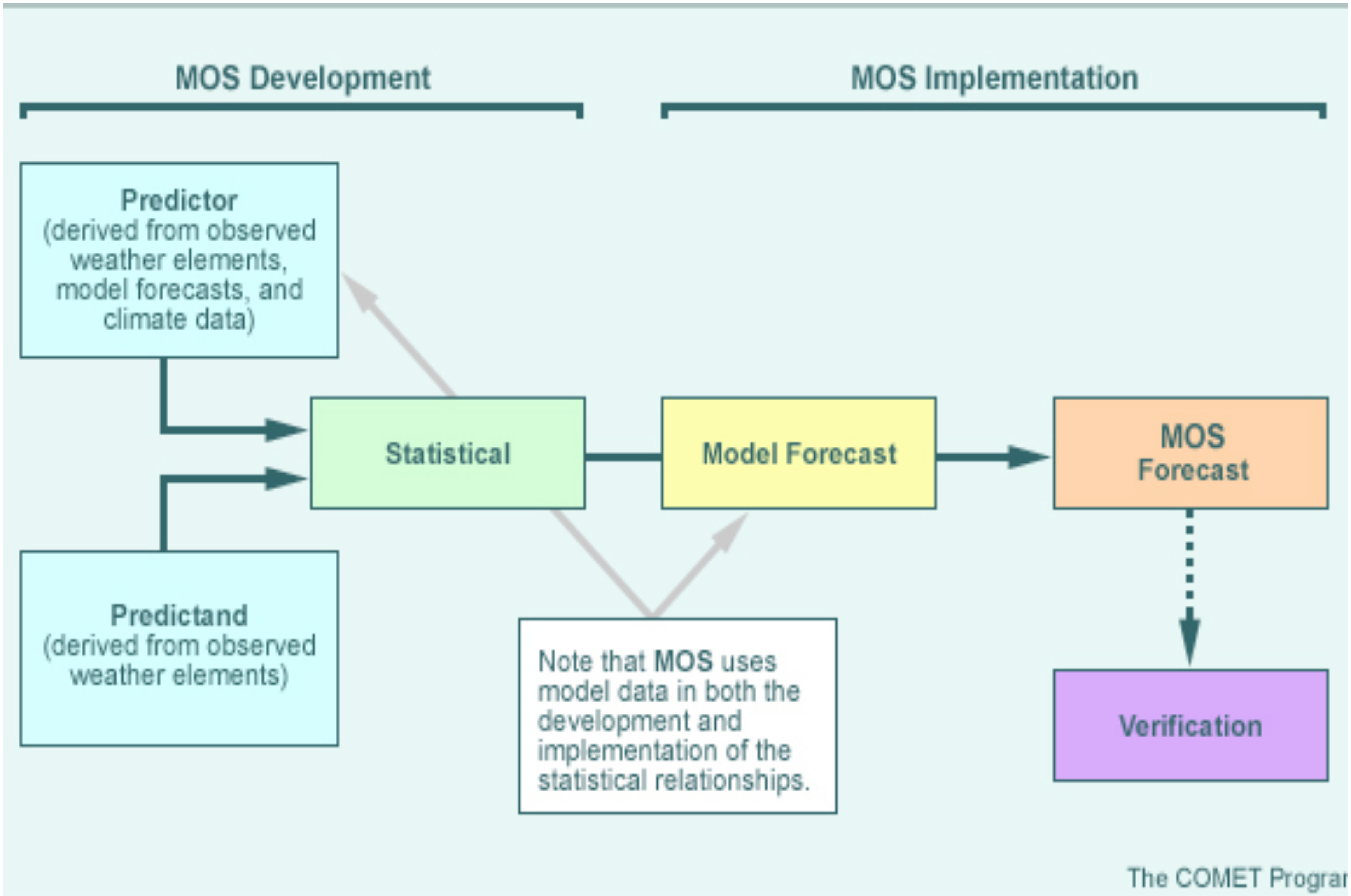
Jones et al (Submitted to BAMS)

PDF for observed future wind speeds (X’)

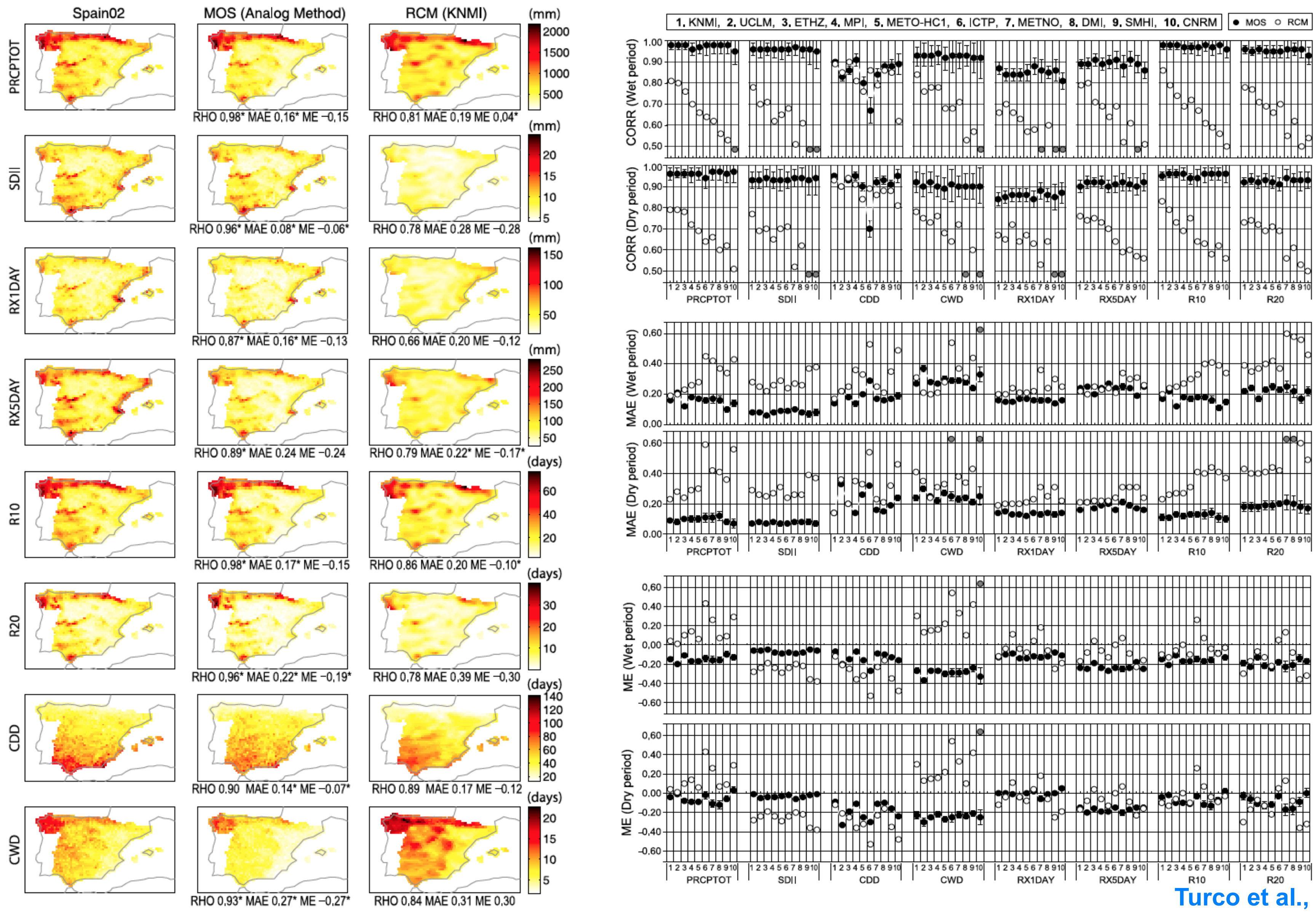


- ❑ Use new parameter estimates to calculate “future” distributions

Model Output Statistics



MOS example



Turco et al., 2011

Q-Q mapping and Analog methods

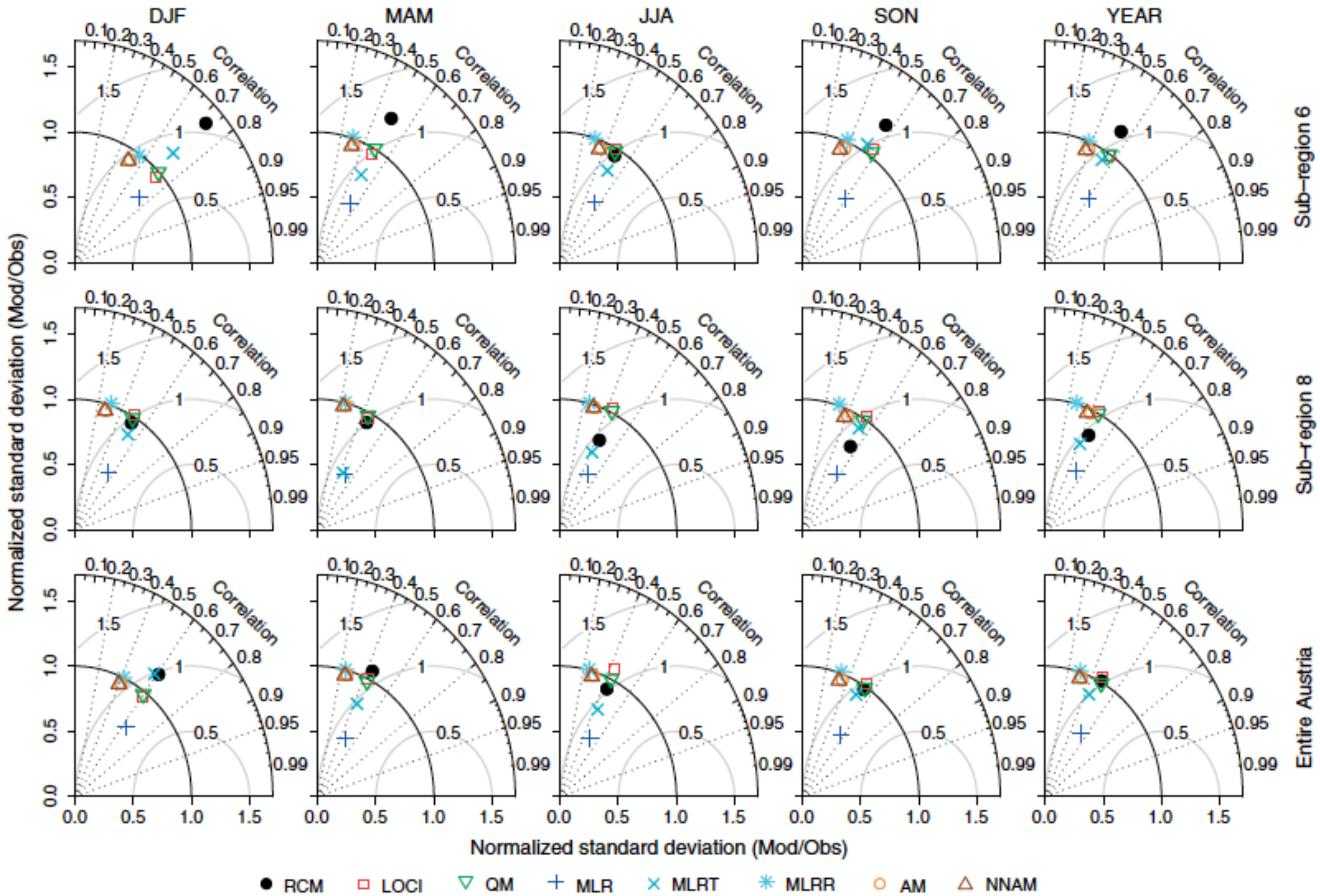
- **Q-Q mapping**

  corrects for errors in the shape of the distribution and is therefore capable to correct errors in variability

- **Analogs**
  - **make use of observed data**
  - **Spatial analog**
    - Select area with climate similar to that predicted
    - Simple but inflexible: limited by availability
  - **Temporal analog**
    - Select time period with desired climate
    - Simple but inflexible: may not have period with predicted properties

Intercomparision of bias correction methods

Precipitation



Jacob etal. 2010

Intercomparision of downscaling methods

The STARDEX project on STAtistical and Regional Dynamical downscaling of Extremes for European regions

Findings:-

- It is impossible to point to the 'best' method for a given region
- temperature can be downscaled with more skill than precipitation
- winter climate can be downscaled with more skill than summer due to stronger relationships with large-scale circulation
- wetter climates can be downscaled with more skill than drier climates
- Bias correction of extreme is most problematic

Advantages/Disadvantages

❑ Advantages:

- Computationally inexpensive/efficient
- Applicable to both GCM and RCM outputs
- Can be used to generate large number of realizations in order to quantify uncertainty
- require only monthly/daily data
- Can relate model output directly to impact relevant variables not simulated by climate models

❑ Disadvantages

- Lack of long/reliable observed series limits the quality of bias correction
- Not physically based
- Assume bias behavior is stationary in time
- Temporal errors of major circulation can not be corrected, e.g. onset of monsoon
- Affected by bias in the GCM/RCM