Pointwise bias correction techniques for model output.

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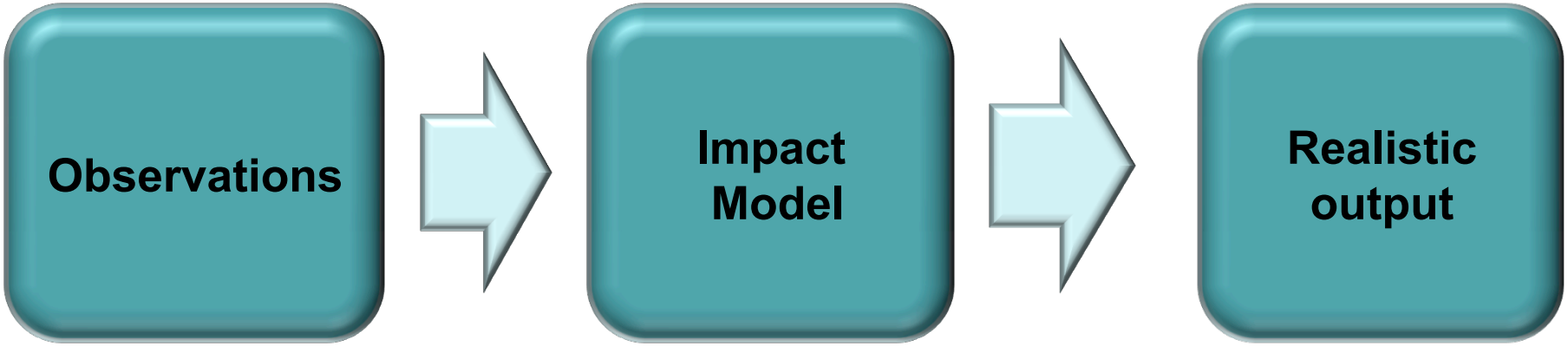
Why do we bias correct model output before using it to force Impact models?



Force an impact model, that performs well when forced with observations, with unprocessed GCM output and you don't get an acceptable result…

•Why?

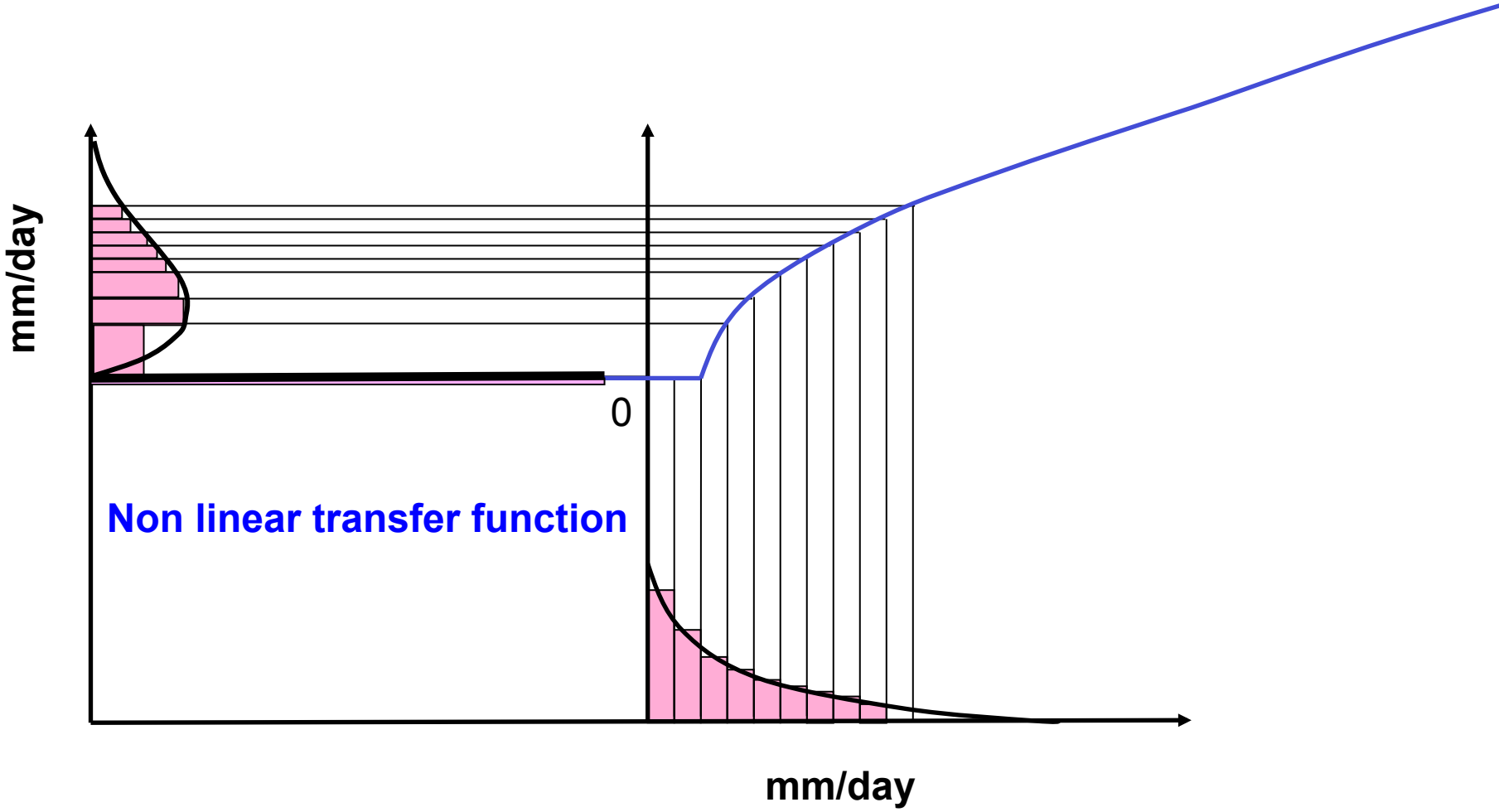
•Gridded precipitation from CGMs is not the same physical variable as the observed:

- •Temporal and spatial averaging.
- •Under-catch corrections
- •Sampling error
- •Other?

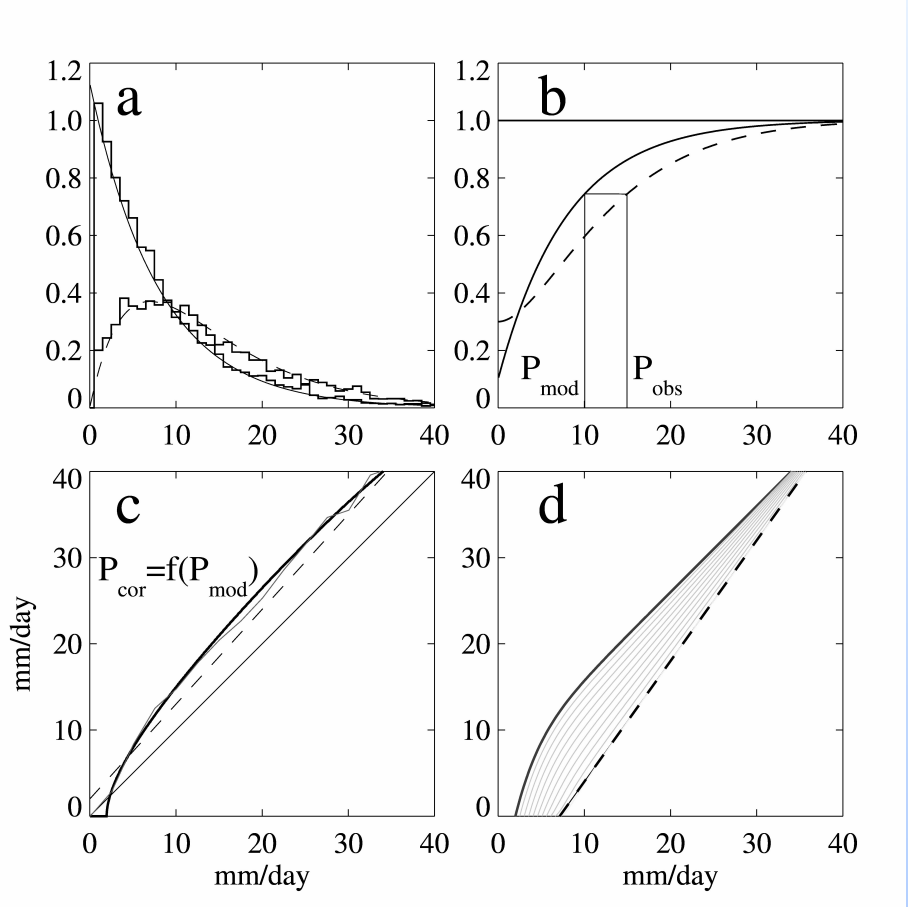
•The GCM daily temperature cycle is physically closer to the observed but there are still differences:

- •Temporal and spatial averaging
- •Ground effects

How histogram matching works



We propose a histogram equalizing methodology



Yes it does work:

a) Idealized histograms of simulated (solid line) and observed (dashed line) daily precipitation.

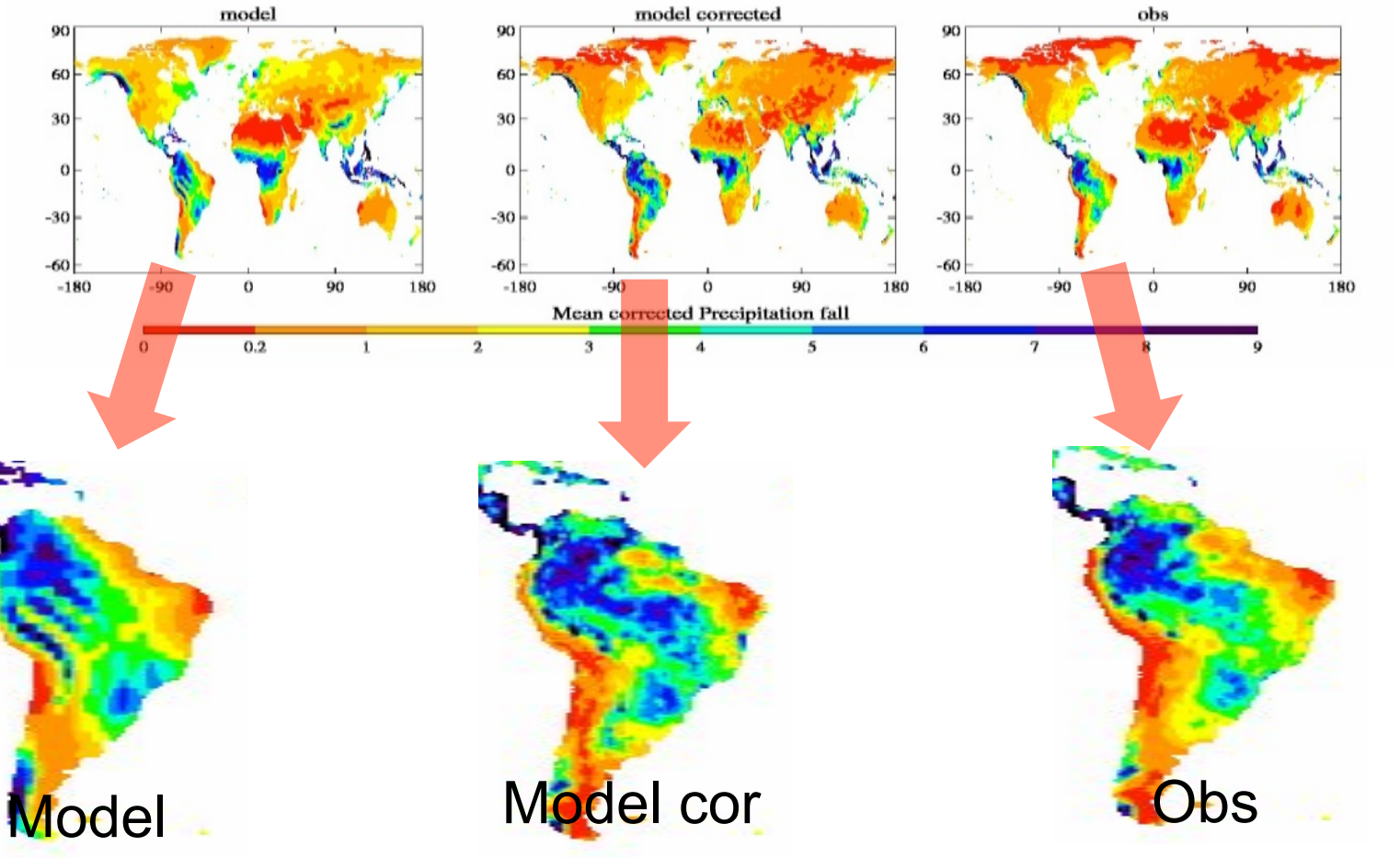
b) Cumulative distributions.

c) Transform function. Is determined by few (< 3) parameters.

d) Transitional daily transform functions

From: Piani et al. 2010

Does the method work?… well yes.



Cross-validation

1990-2000 January precipitation over South America corrected using 1960-1970 transfer function.

What are some of the outstanding problems?

•Statistical bias corrections are couched in uncertainty. The difference between Bias and Error depends on the length of the simulation.
•**Suggested solution**: Analysis of transfer function spread.
(Piani et al., 2010b)
, comparative analysis of uncertainty from BC and other sources
(Chen et al., 2011)

•So far we have corrected temperature and precipitation separately. No improvements are made in the representation of the dynamical relations between the two variables.
•**Suggested solution**: undertake full 2D statistical bias correction.
(Piani et al., 2011)

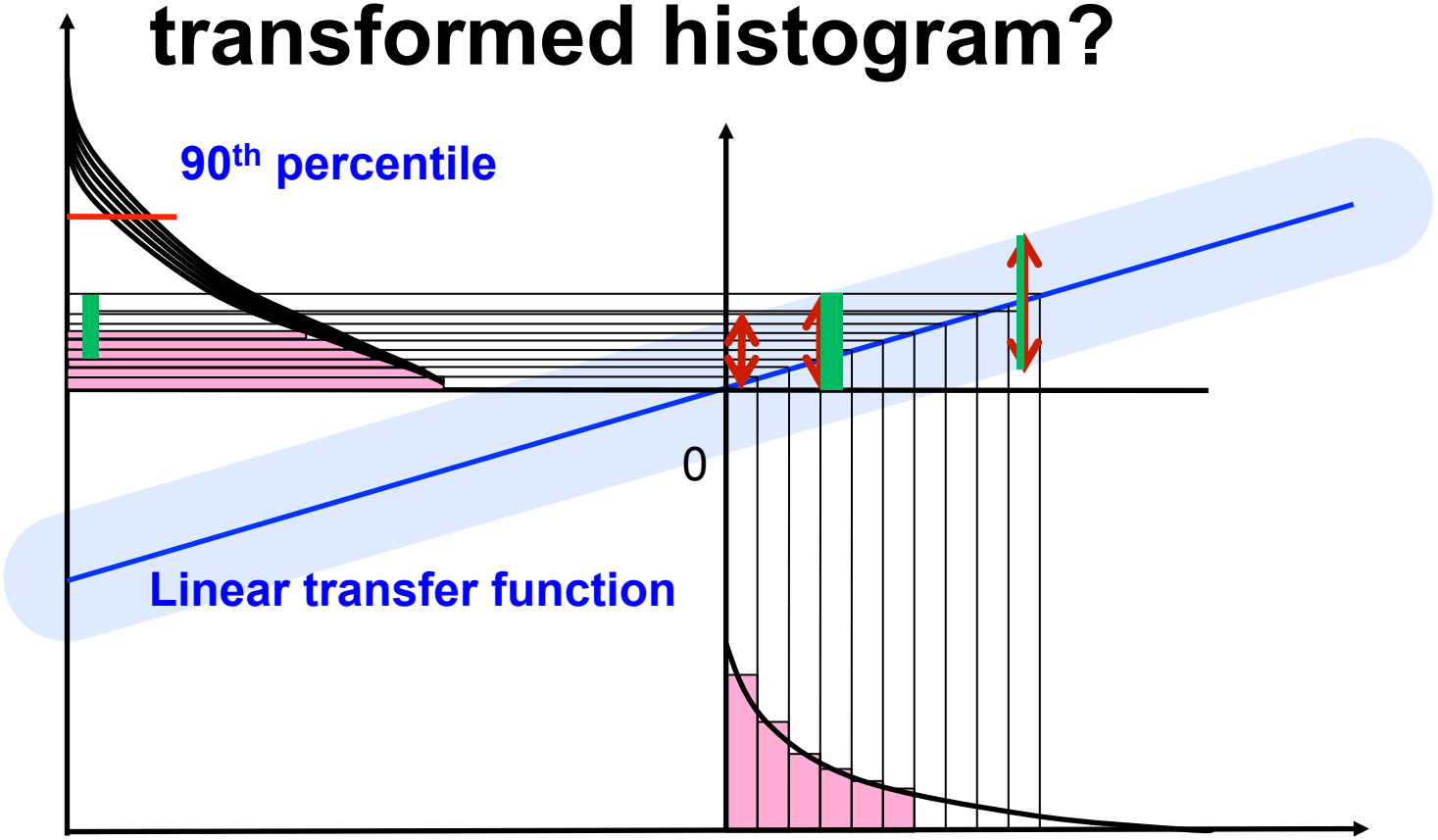
•Corrections are not independent on time scale: if you correct the daily variance you do not correct the monthly variance.
•**Suggested solution**: the cascade statistical bias correction.
(*Haerter and Piani, 2011*)

Uncertainty in the bias correction (TF)

•Fits to the transform function are associated with uncertainty from different sources:

- Standard error associated with fit (negligible).
- Choice of fitting function. (can be made negligible, trade-off with robustness)
- Decadal variability of fit parameters. (*This is the big one…*)

How does uncertainty in the TF affect the transformed histogram?



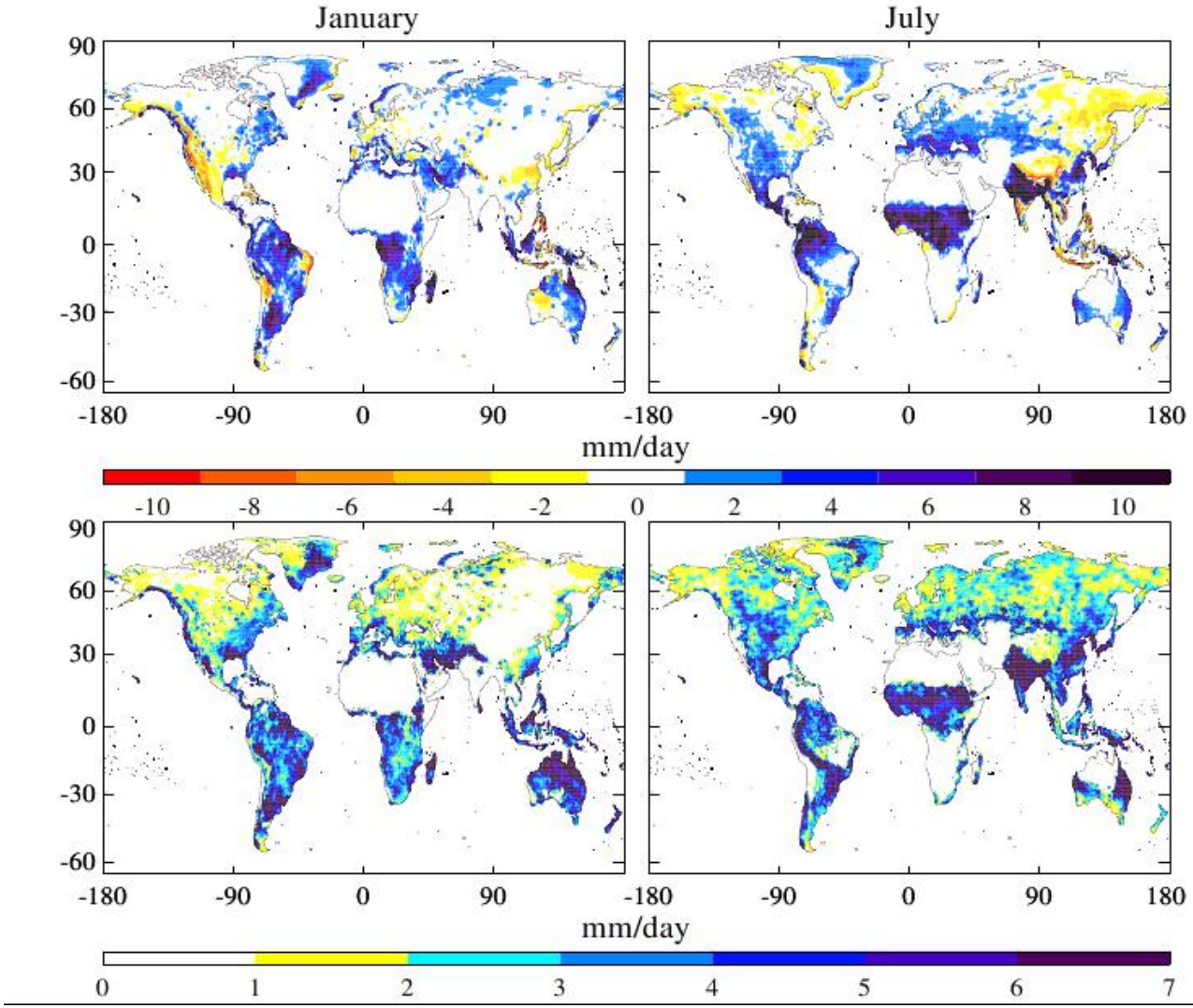
•How can we produce a horizontal mapping of the bias-correction-induced uncertainty? (*ex.: precipitation*):

•Plot the average additive correction for the 90th percentile of the local precipitation intensity distribution in mm/day.

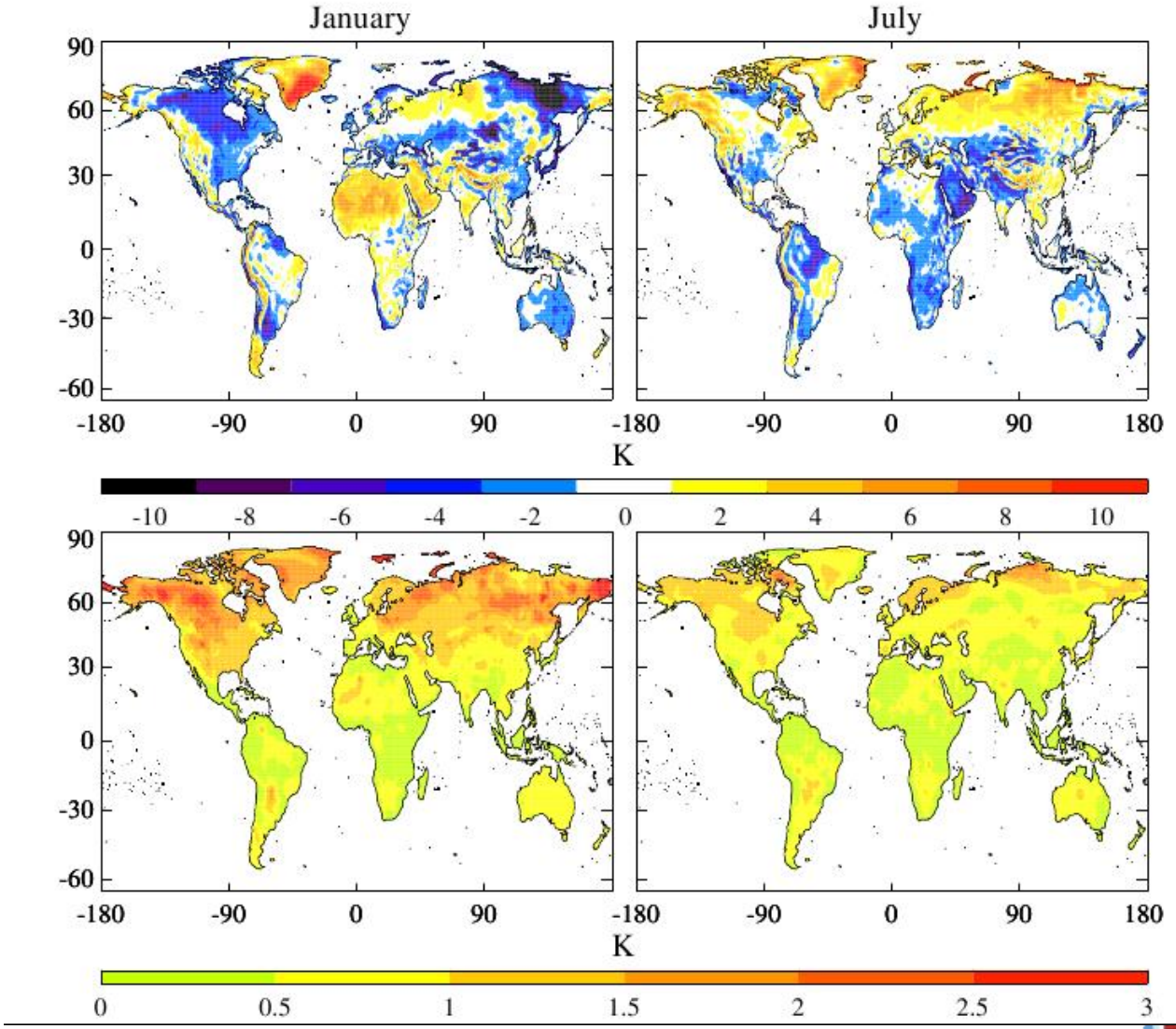
• The average is computed over the 12 separate *TFs* obtained using the 3 members of the ECHAM5 ensemble alternatively with the 4 decadal periods form 1960 to 1999.

• Plot the standard deviation across the 12 *TFs* for the same intensity percentile.

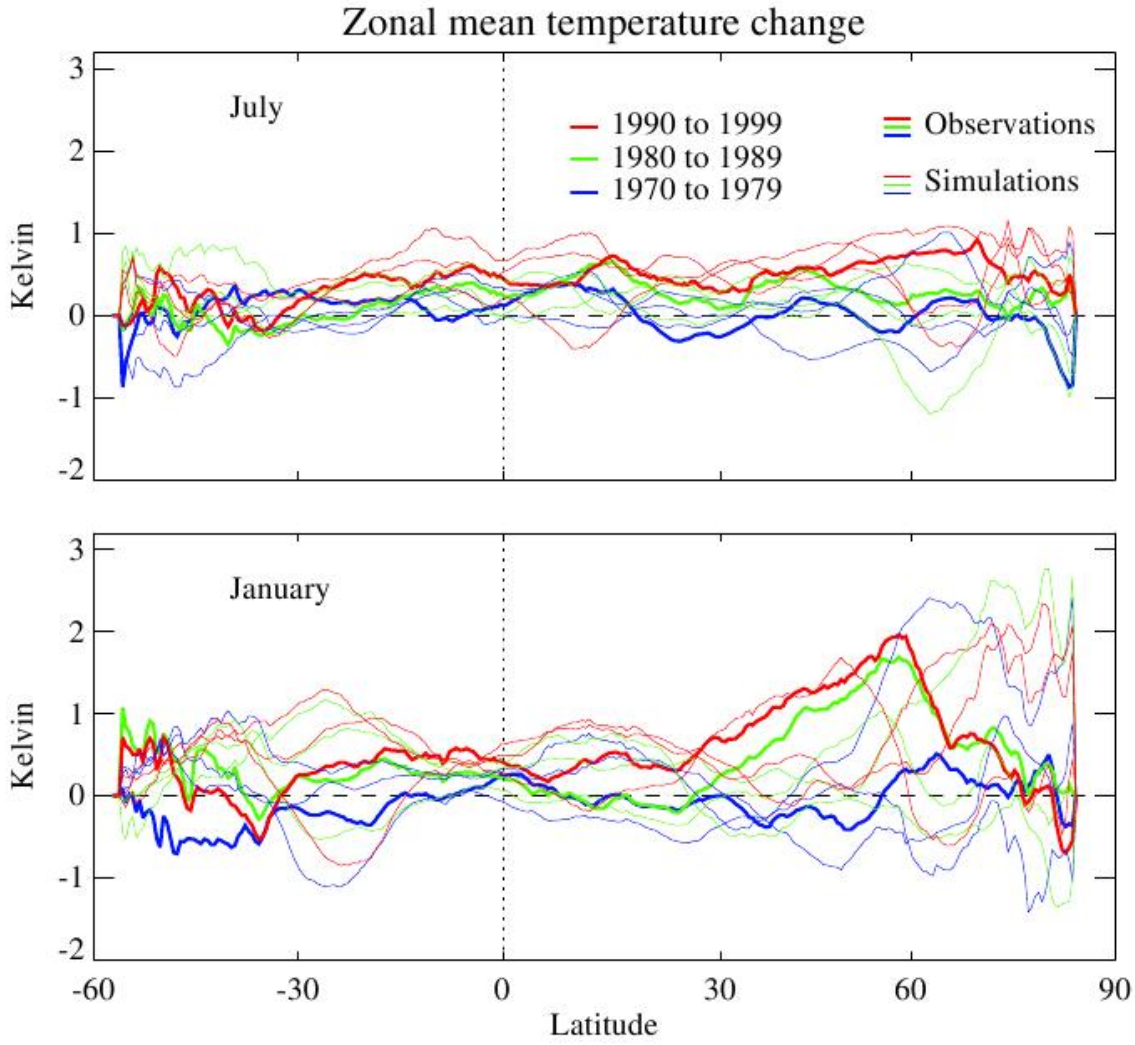
Uncertainty in the bias correction for daily precipitation.



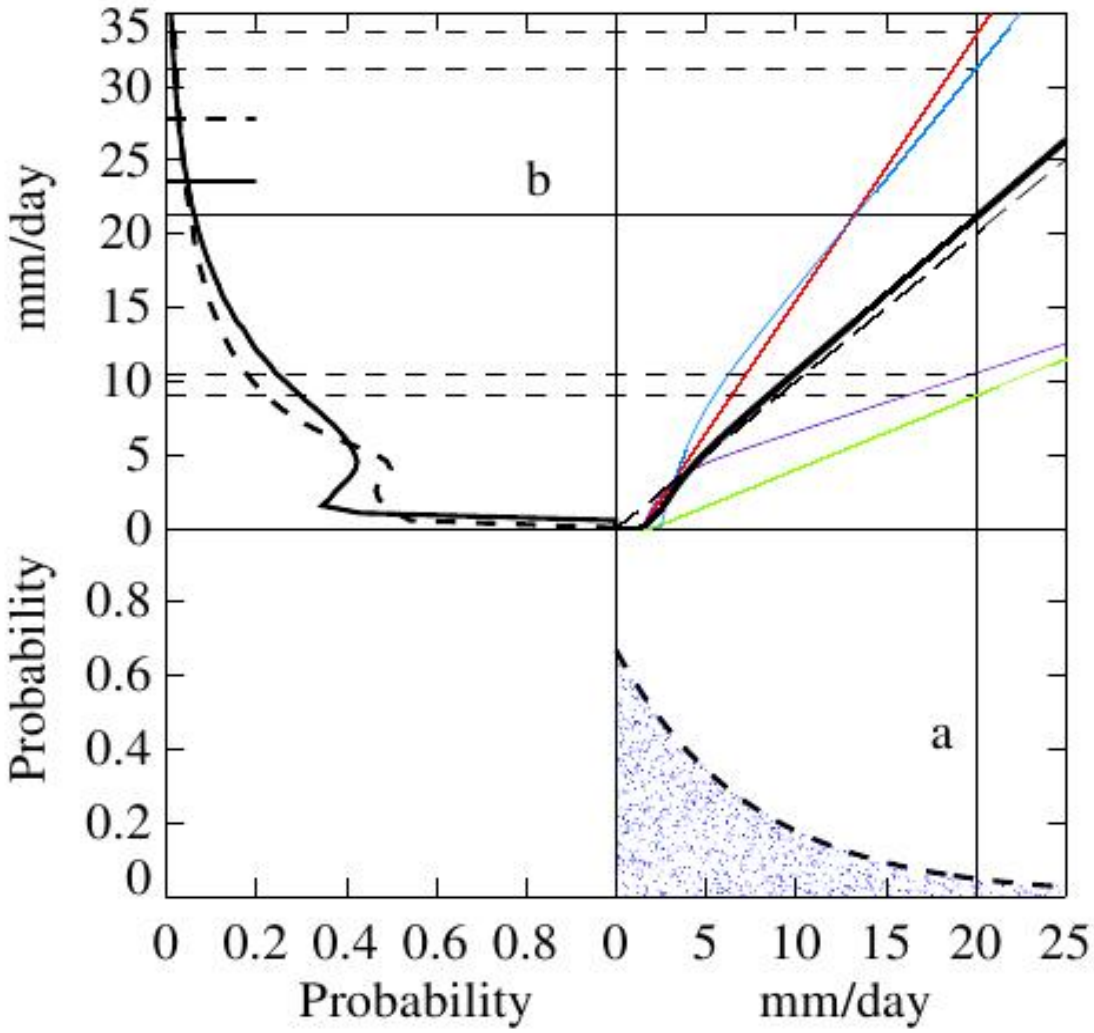
Uncertainty in the bias correction for daily temperarure.



Decadal variability of zonal mean temperature.



Accounting for uncertainty in the bias correction.



Uncertainty conclusions

•Using all four decades of observational data available and all members of the initial condition ensemble of simulations, we were able to give qualitative descriptions of the horizontal distribution of the uncertainty associated with the bias corrected fields.

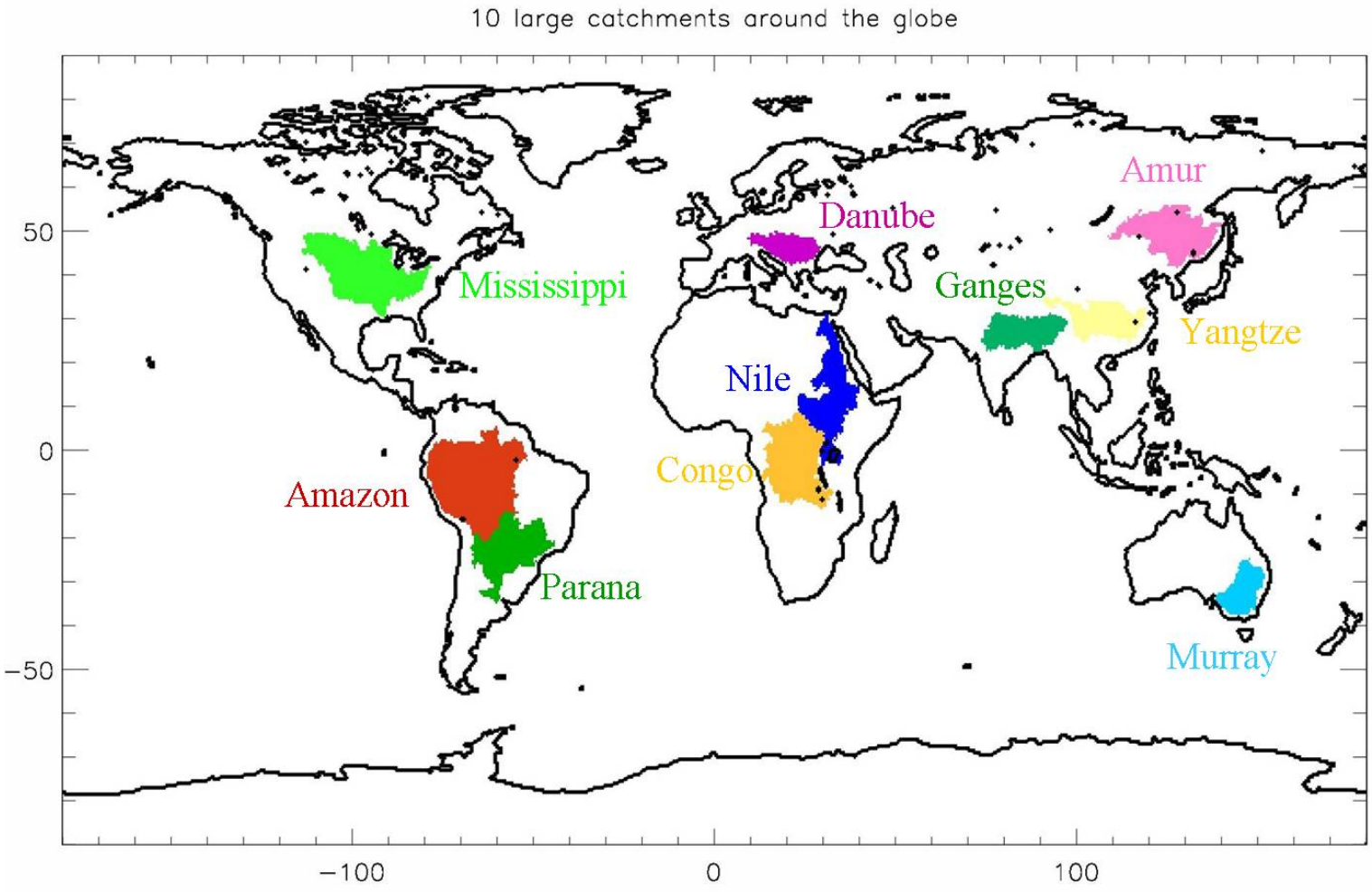
•For precipitation the larger uncertainties are located roughly where large corrections in the frequency of intense precipitation events are applied.

• This is not the case for the 3 temperature fields.

• We propose a very simple method to account for the emerging inter-decadal variability of the *TFs* in probabilistic threshold type projections. *We believe this could become an essential tool for end users in the water resource planning community.*

•*What is the comparative contribution in hydrological forecasts?*

Selected major basins

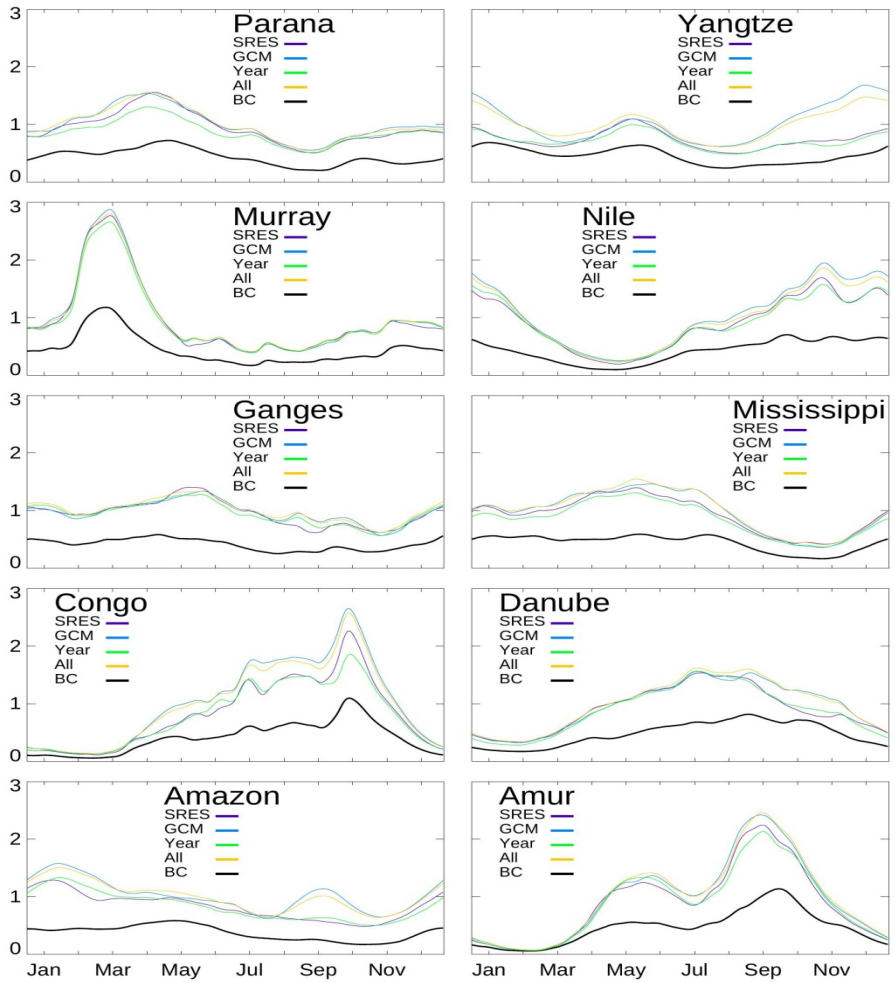


Experiment outline:

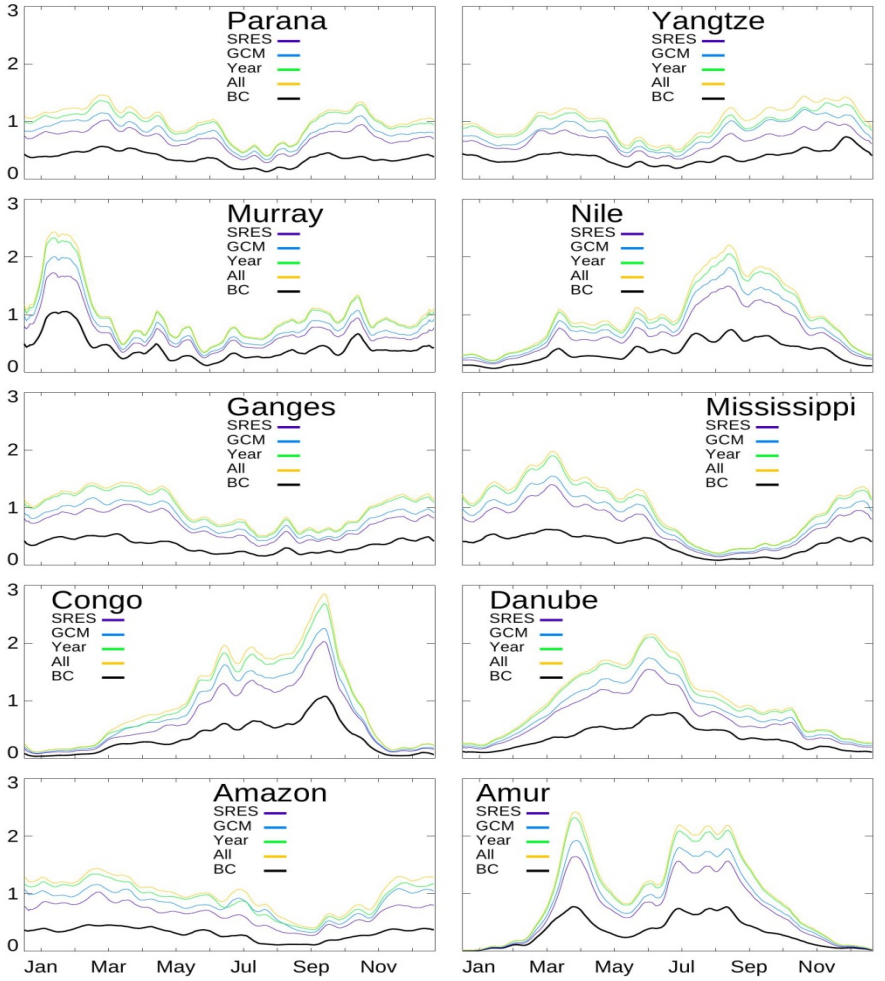
3 GCMs x 2 SRESs x 4 BCs x 15 years

Uncertainty from BC, GCM, SRES compared with interannual variabiity.

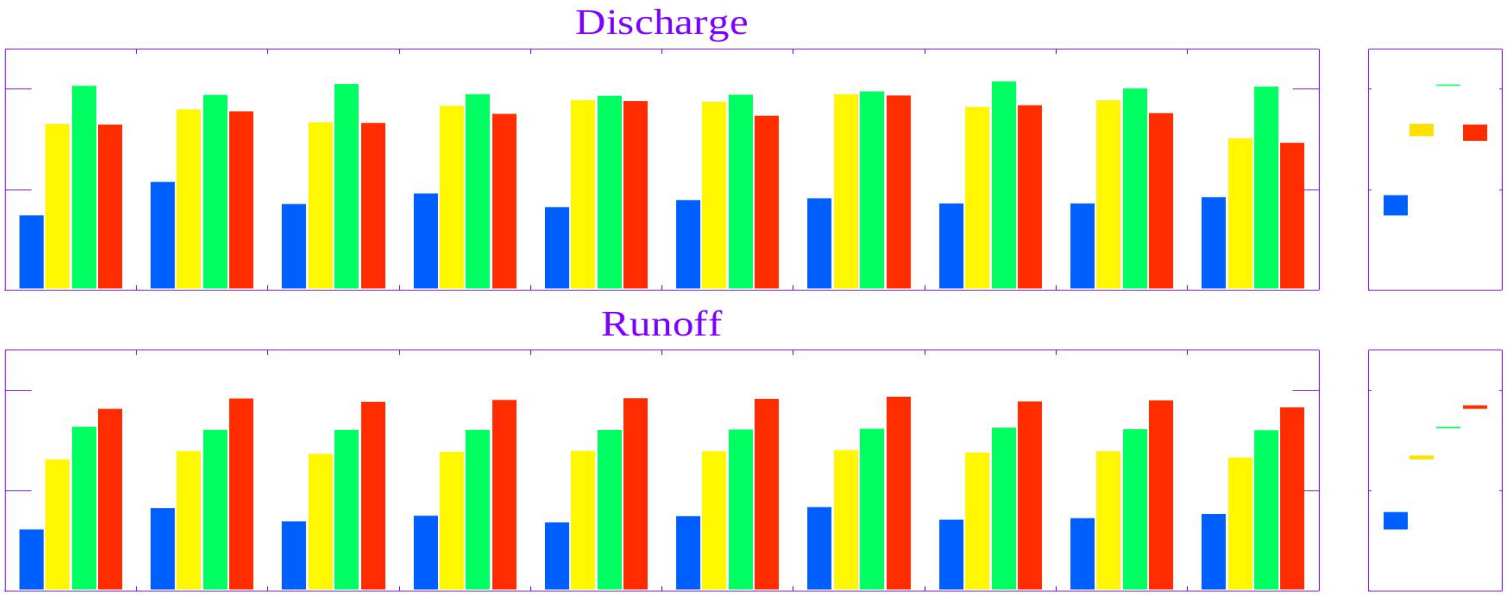
Discharge



Runoff

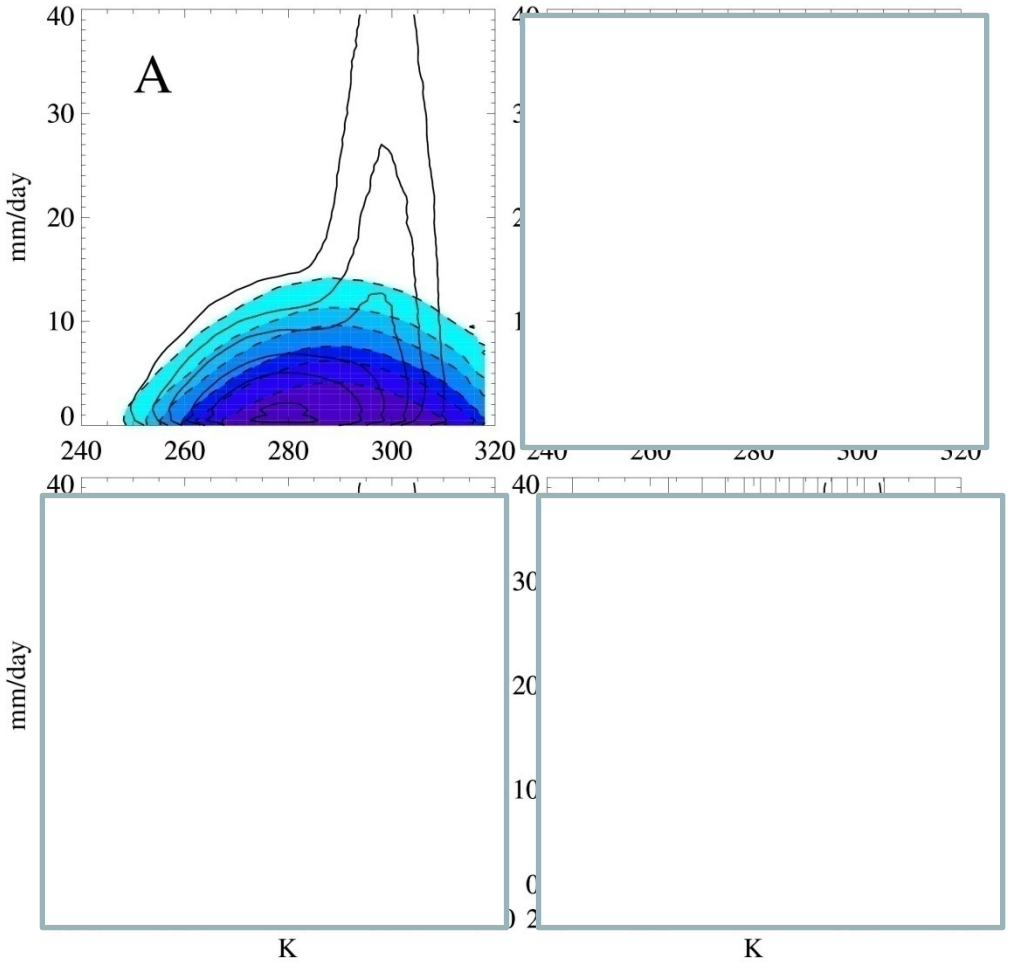


Uncertainty contribution averaged across annual cycle.



The choice of decade for the bias correction calibration appears to give the smallest contribution to uncertainty.

2D statistical bias correction of temperature and precipitation (2D histogram matching).



A) Idealized 2D histograms of simulated (colored contours) and observed (solid contours) daily precipitation and temperature.

B) Like **A**, but the simulations have been independently corrected with a linear Transfer Function.

C) Like **B**, but the simulations have been independently corrected with a perfect Transfer Function.

D) Like **B**, but the simulations have been corrected with a 2D linear Transfer Function.

Conclusions 2D correction

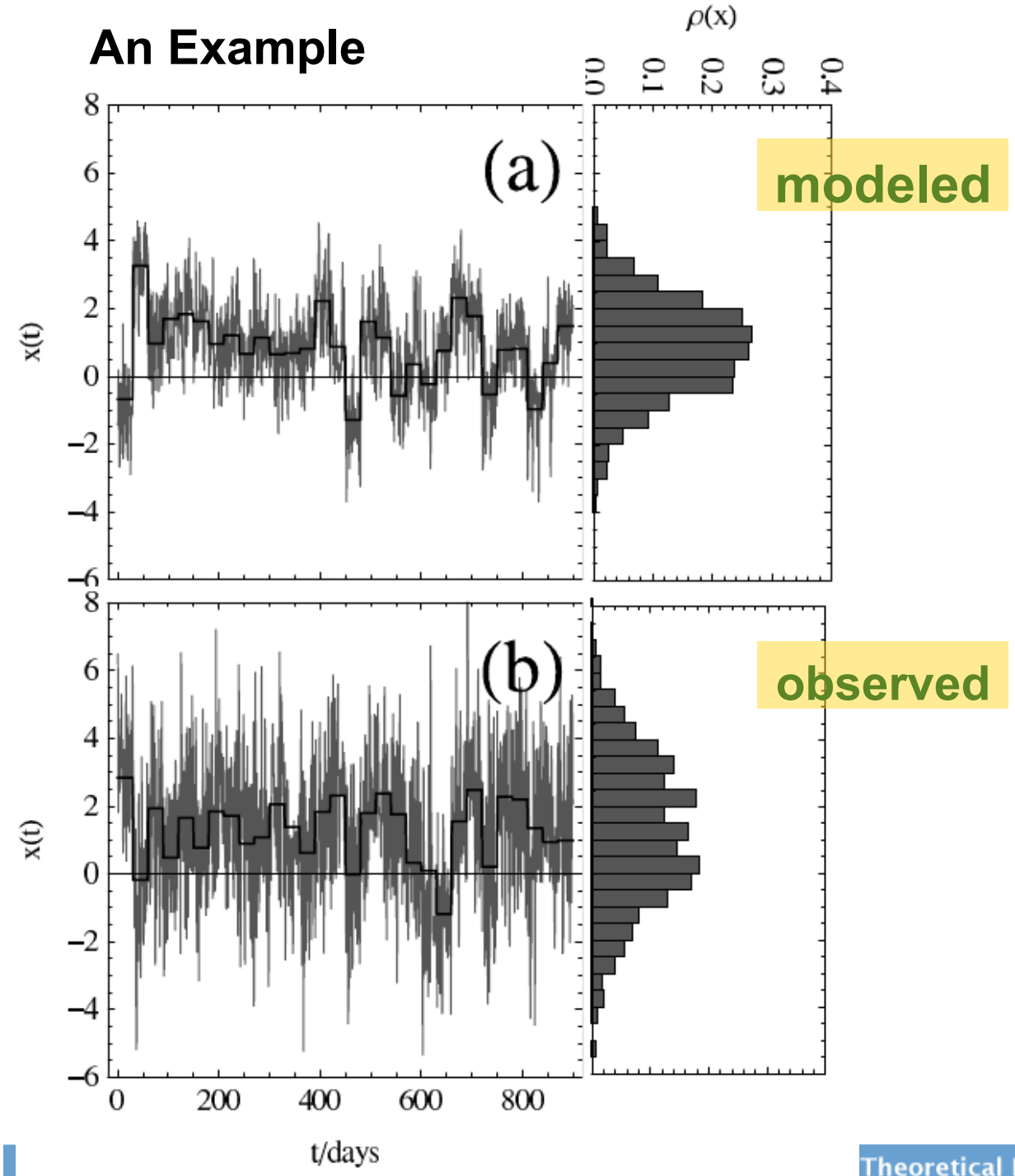
•2D Bias equalizations effectively reproduces the structure of the observed multivariate spectrum.

•2D Bias correction has very high observational requirements which limit its applicability to gridded output.

Bias Corrections are dependent on time scale.

i.e. if you correct the variance of daily data you do not correct the variance of monthly data.

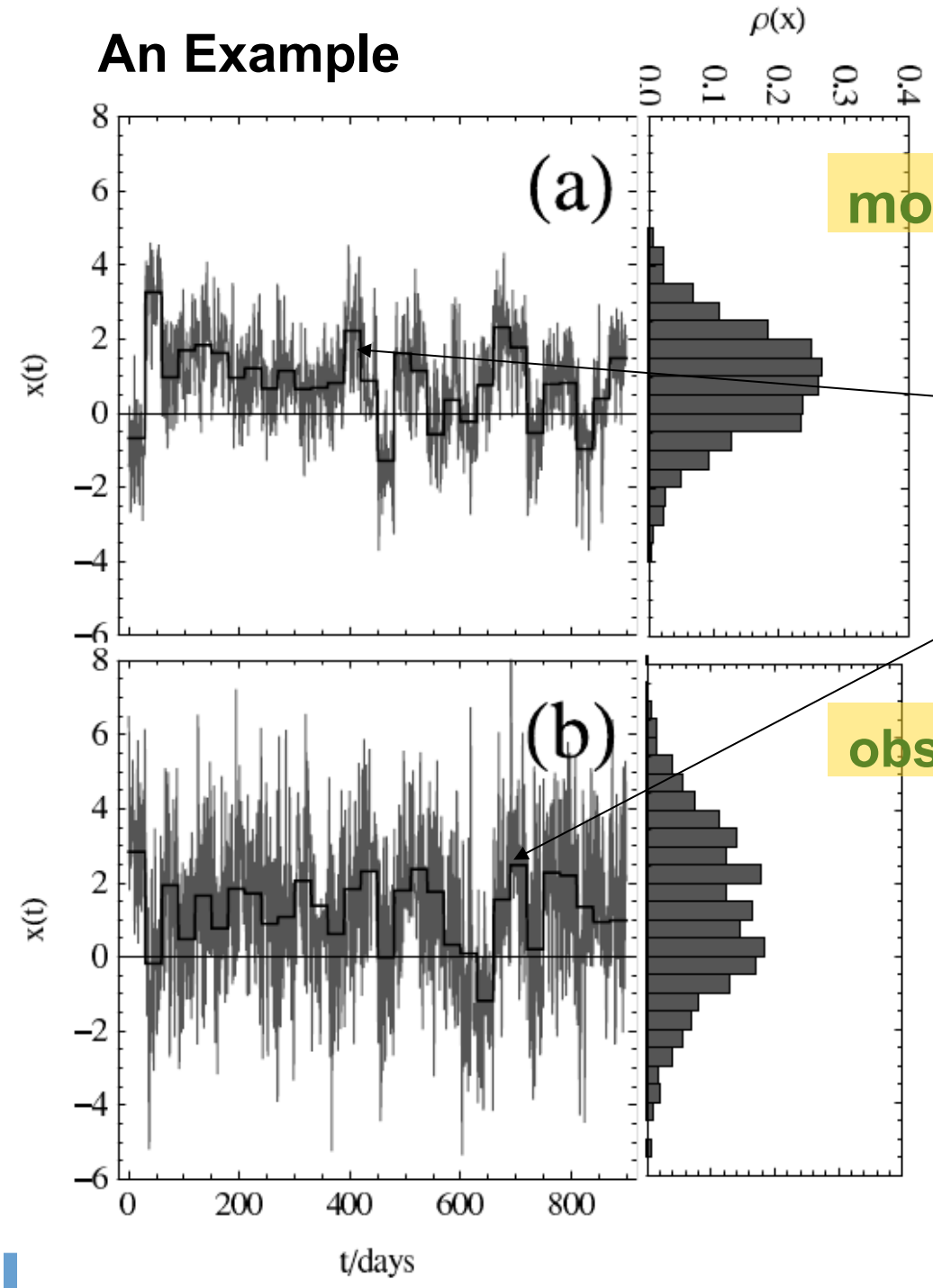
An Example



modeled

observed

An Example

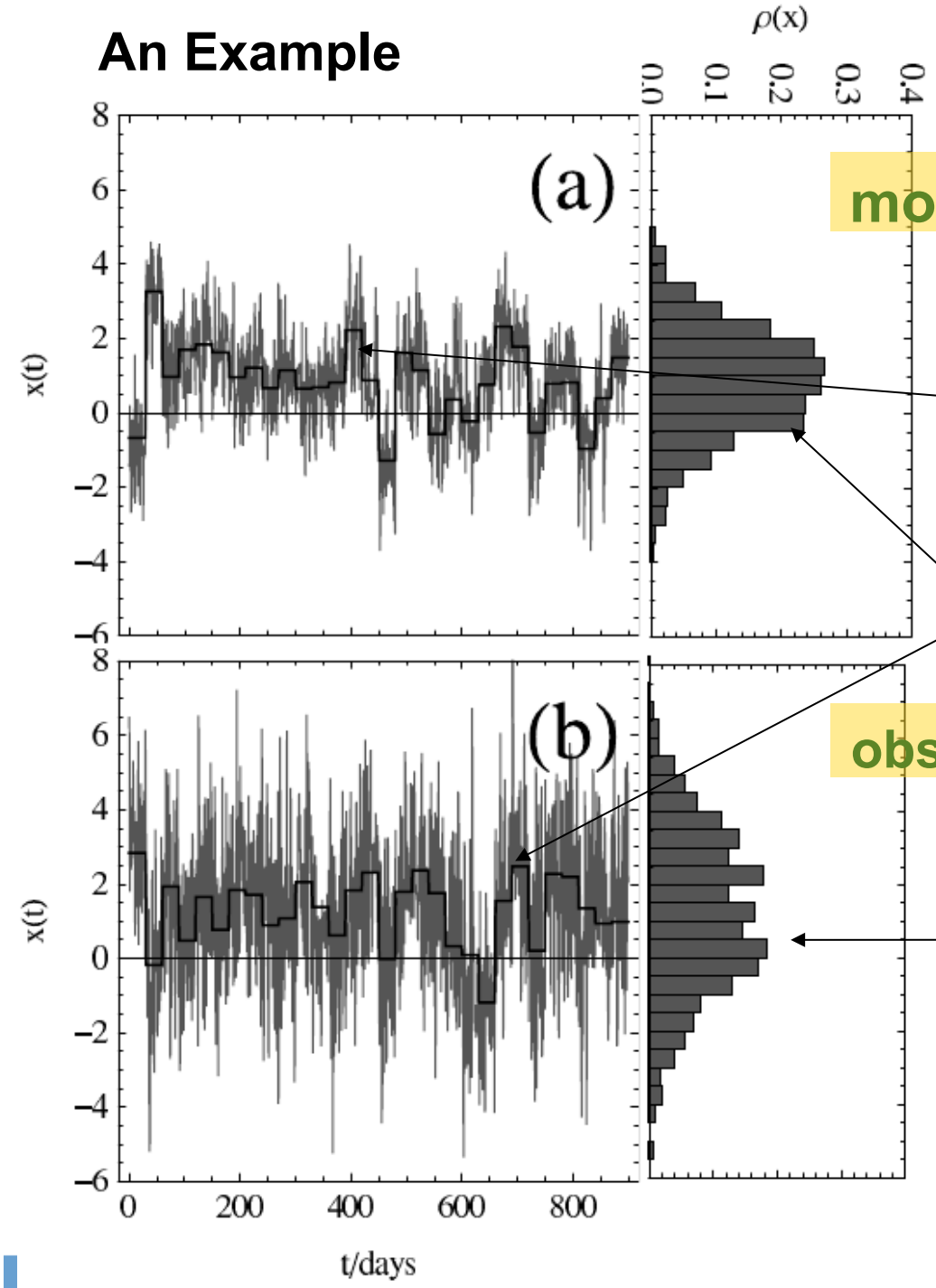


modeled

observed

Identical distribution function of the monthly means

An Example



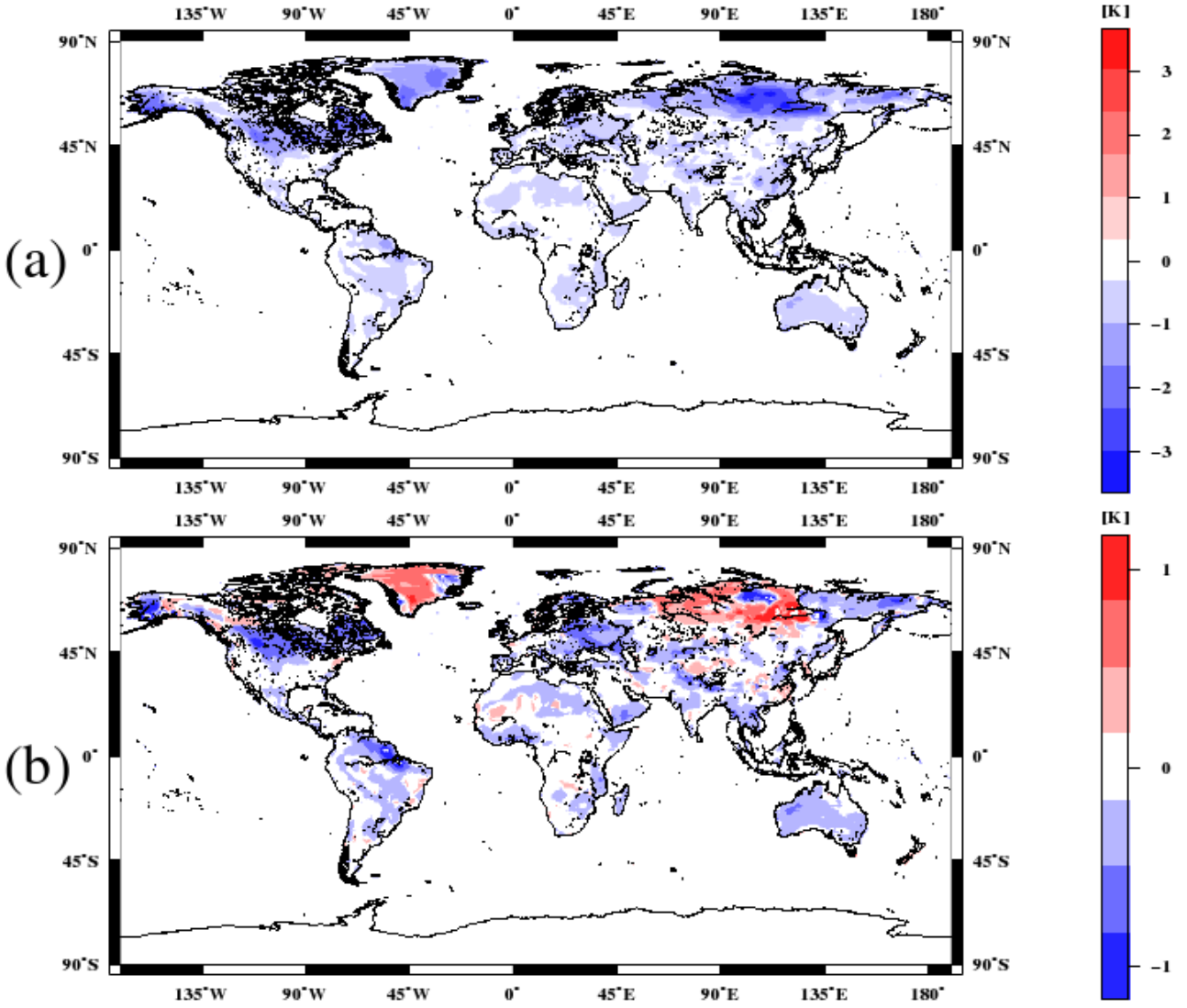
modeled

observed

Identical distribution function of the monthly means

Different distribution functions of daily data

Improvement of Variance through standard bias correction

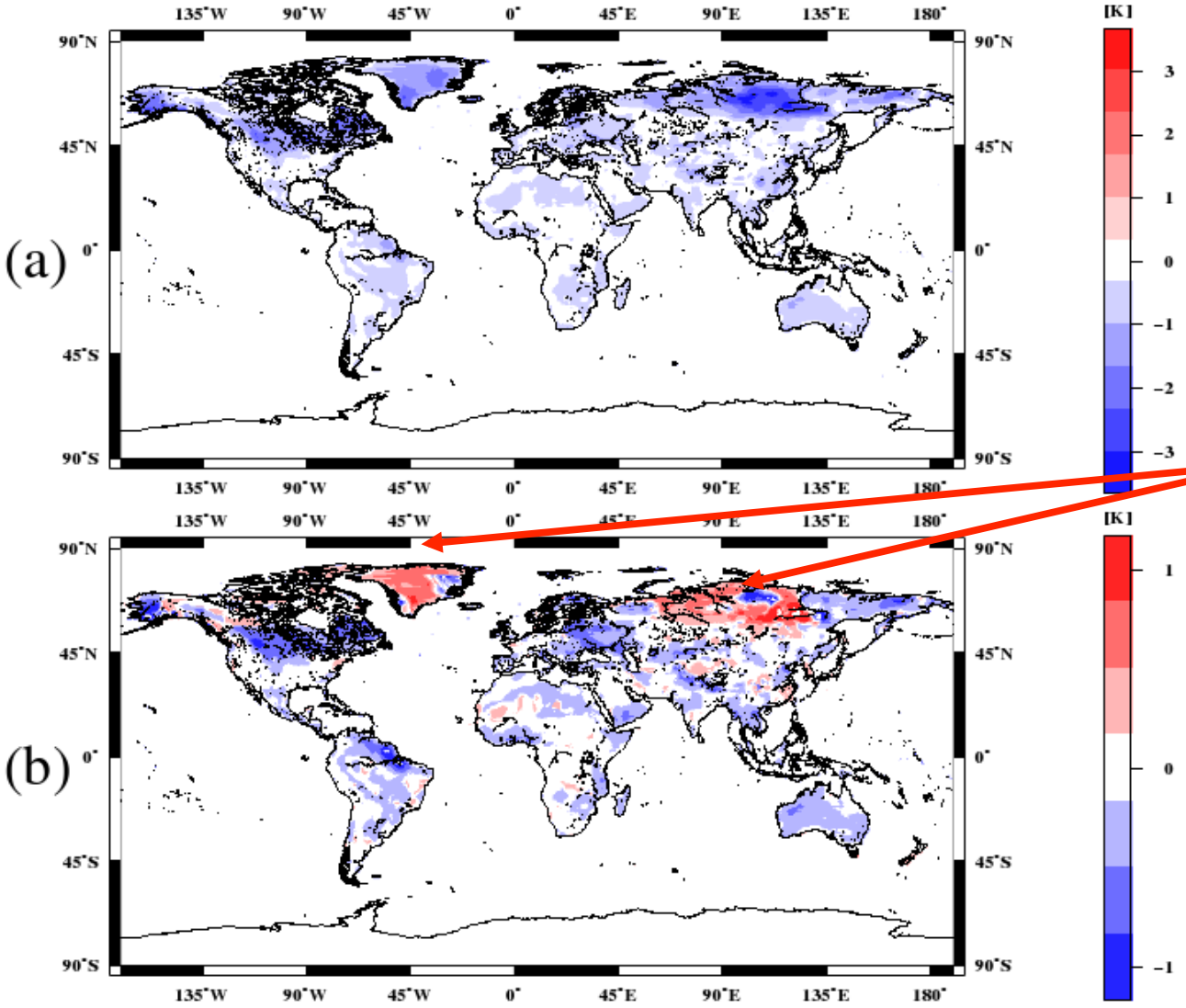


daily

monthly

$$\Delta SD(T) = |SD(T_{mod,cor}) - SD(T_{obs})| - |SD(T_{mod,org}) - SD(T_{obs})|$$

Improvement of Variance through standard bias correction



daily

Results have worsened!

monthly

$$\Delta SD(T) = |SD(T_{mod,cor}) - SD(T_{obs})| - |SD(T_{mod,org}) - SD(T_{obs})|$$

Cascade bias correction method (Haerter et al.)

1. produce relative fluctuations

$$T'_{i,j} \equiv T_{i,j} - \bar{T}_j$$

Temperature at day i of month j

Mean of month j

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Transfer function for daily fluctuations

$$T'^{cor}_{l,k} = f_{daily}(T'_{l,k})$$

2. produce bias correction to daily relative fluctuations

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3. produce bias correction to monthly mean fluctuations

$$\bar{T}^{cor}_{l} = f_{monthly}(\bar{T}_l)$$

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Temperature at day i of month j

Mean of month j

2. produce bias correction to daily relative fluctuations

Transfer function for daily fluctuations

$$T'^{cor}_{l,k} = f_{daily}(T'_{l,k})$$

3. produce bias correction to monthly mean fluctuations

$$\bar{T}^{cor}_{l} = f_{monthly}(\bar{T}_l)$$

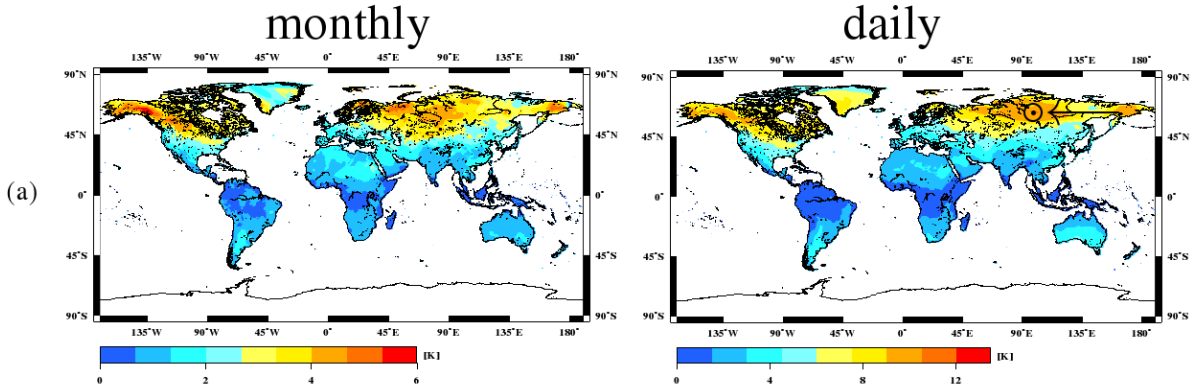
4. re-assemble the bias corrected time series

$$T^{cor}_{l,k} = \bar{T}^{cor}_{l} + T'^{cor}_{l,k}$$

Corrected monthly

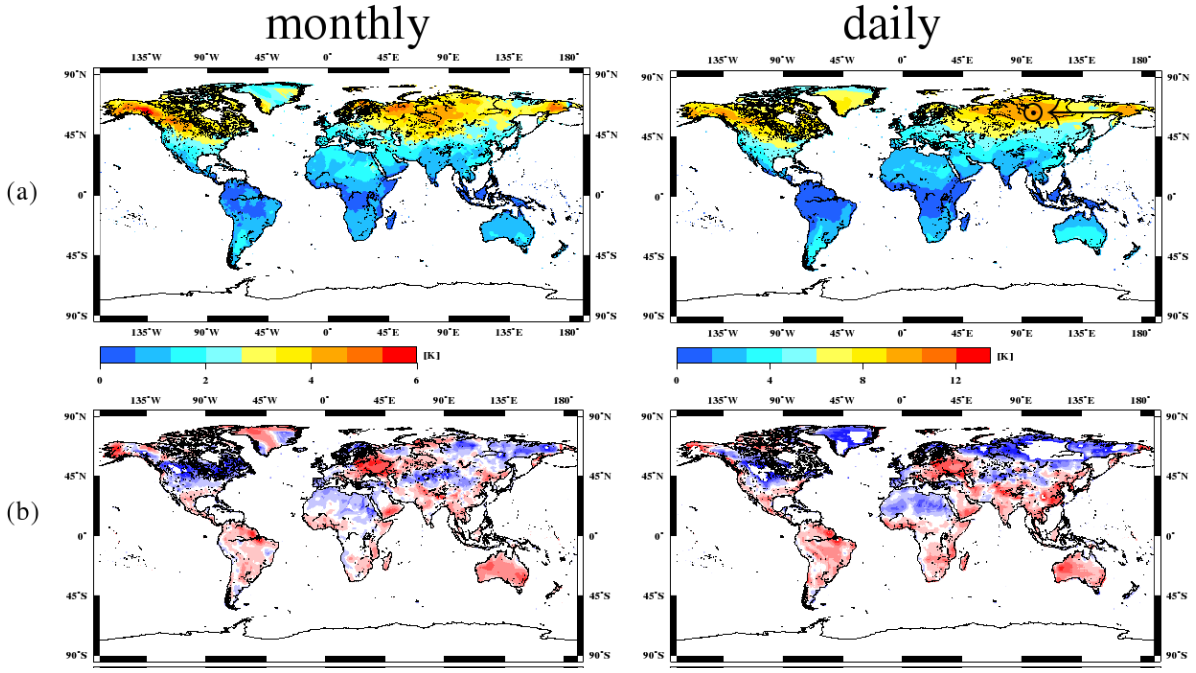
Corrected daily

Standard deviation of WFD, difference to model, standard corrected model, cascade corrected model



WFD

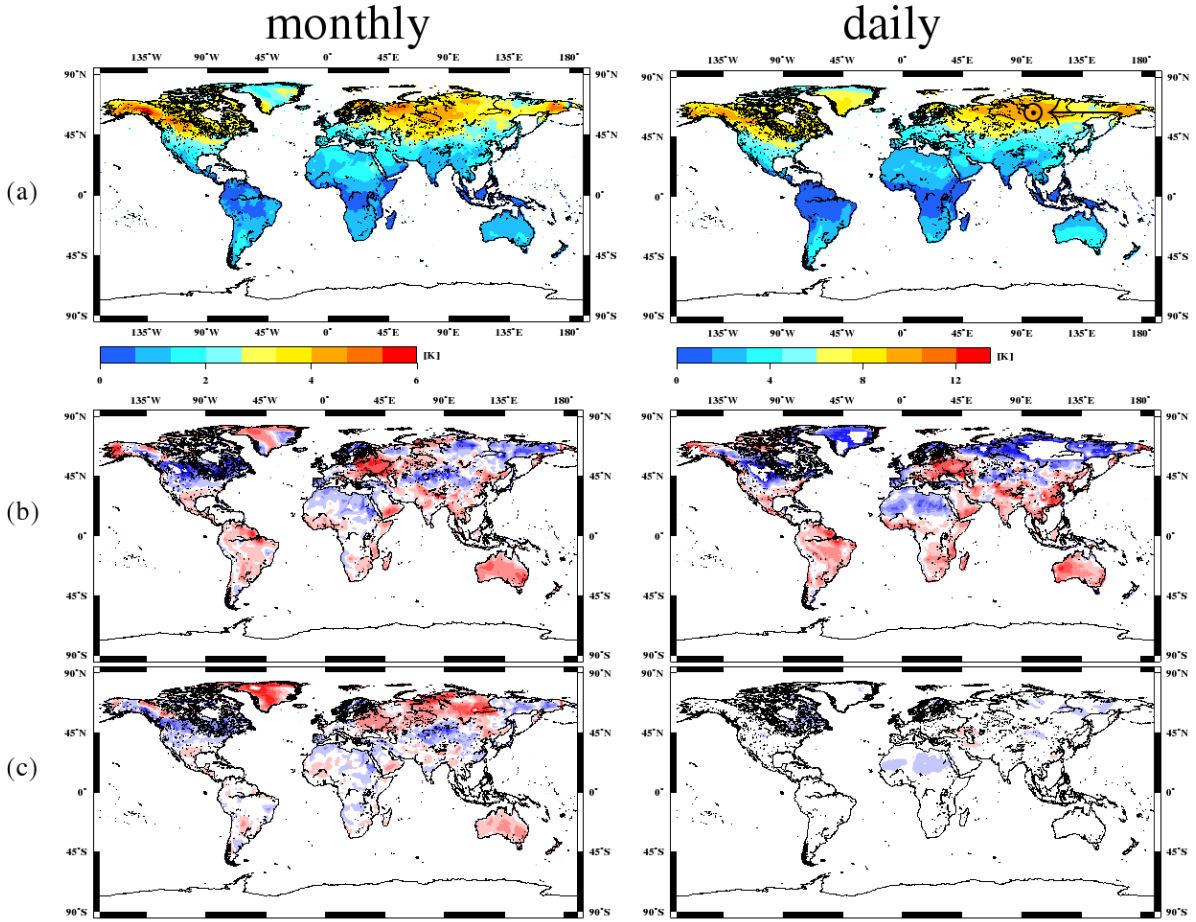
Standard deviation of WFD, difference to model, standard corrected model, cascade corrected model



WFD

uncorrected model

Standard deviation of WFD, difference to model, standard corrected model, cascade corrected model

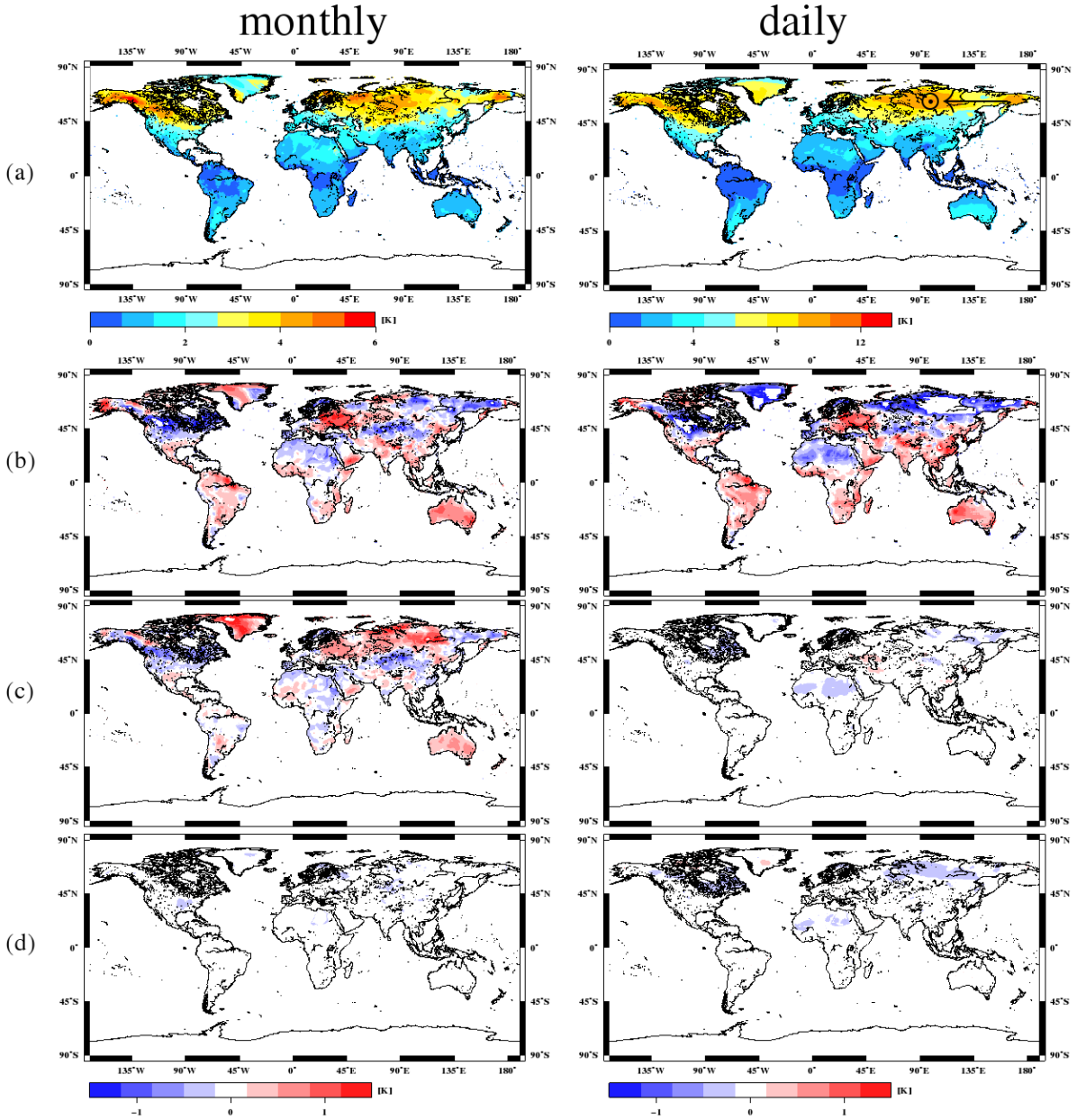


WFD

uncorrected model

Standard corrected model

Standard deviation of WFD, difference to model, standard corrected model, cascade corrected model



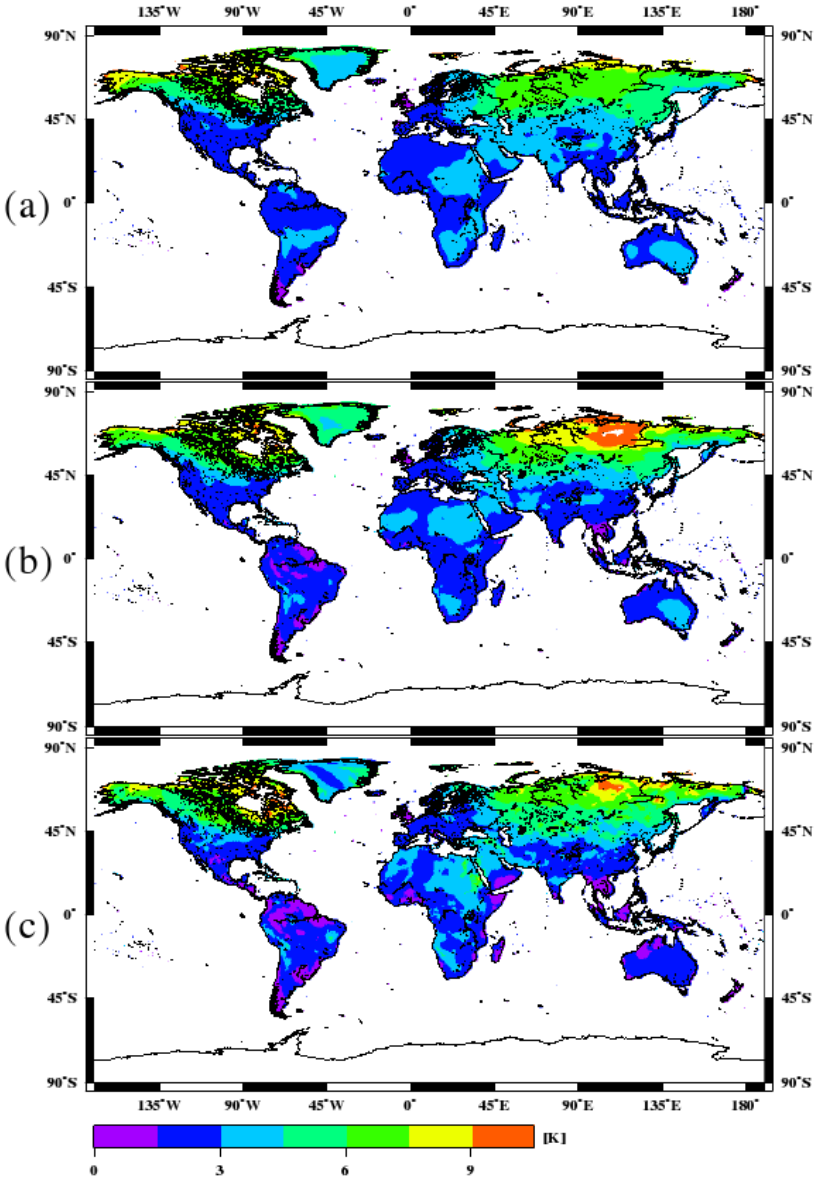
WFD

uncorrected model

Standard corrected model

Cascade corrected model

The big question: How do the different methods impact on the climate change signal?

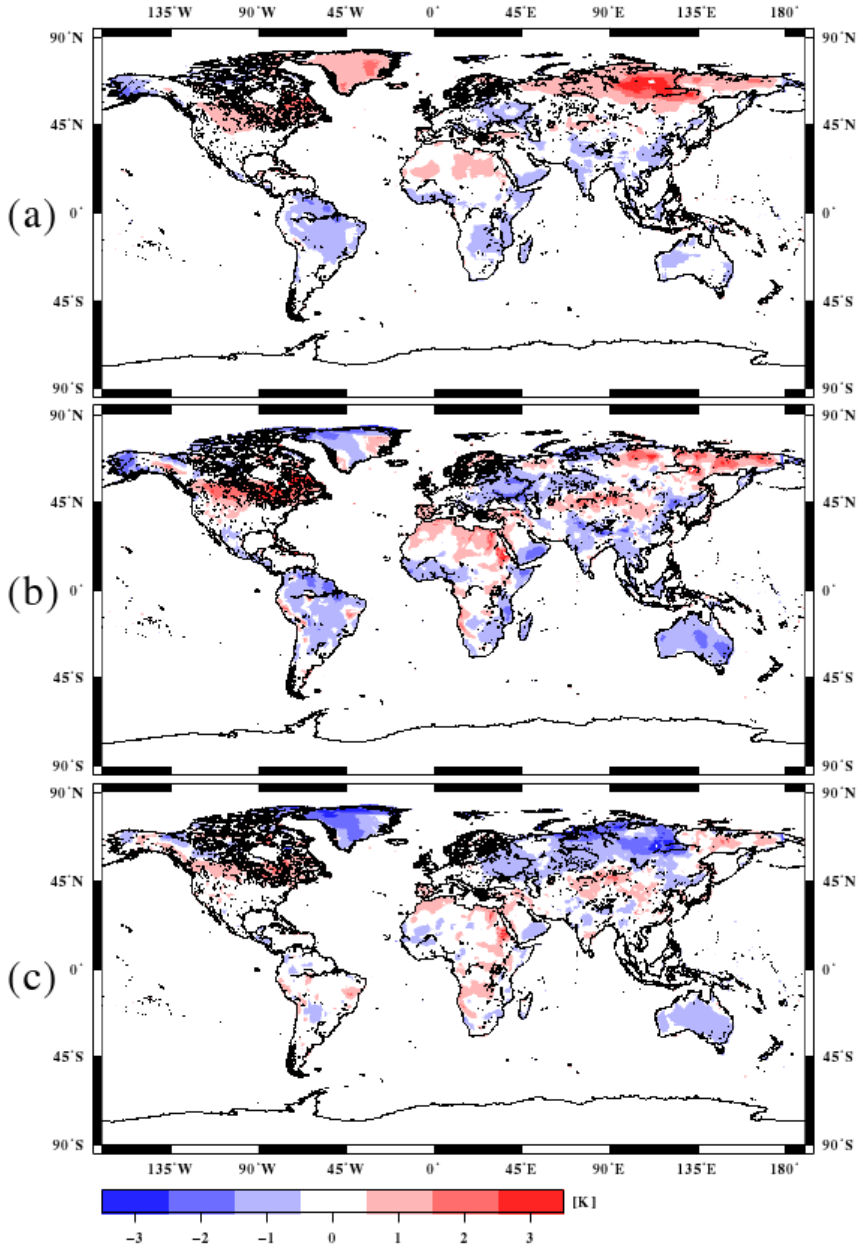


No bias correction

Standard bias correction

Cascade bias correction

The big question: How do the different methods impact on the climate change signal?



Change with standard BC

Change with cascade BC

Cascade-standard

Conclusions

- Statistical Bias Corrections perform transformations to entire PDF, hence, **mixing of timescales**
- Improvement on one timescale may imply worsening on another
- Therefore: better to perform **cascade bias correction** which **keeps timescales separate**
- Future climate change signal is impacted upon by bias correction