How reliable are selected methods of projections of future thermal conditions? A case from Poland

Joanna Wibig

Department of Meteorology and Climatology,
University of Łódź,

Climate Change - The environmental and socio-economic response in the southern Baltic region,
Szczecin, Poland, 12 - 15 May 2014

Outline

1. Motivation

- Requirements of climate change impact studies
- Sources of uncertainties in climate projections

2. Data

3. Bias correction methods

4. Evaluation of methods

- Mean
- Standard deviation and skewness
- Extremes

5. Conclusions

Examples of climate change impact studies

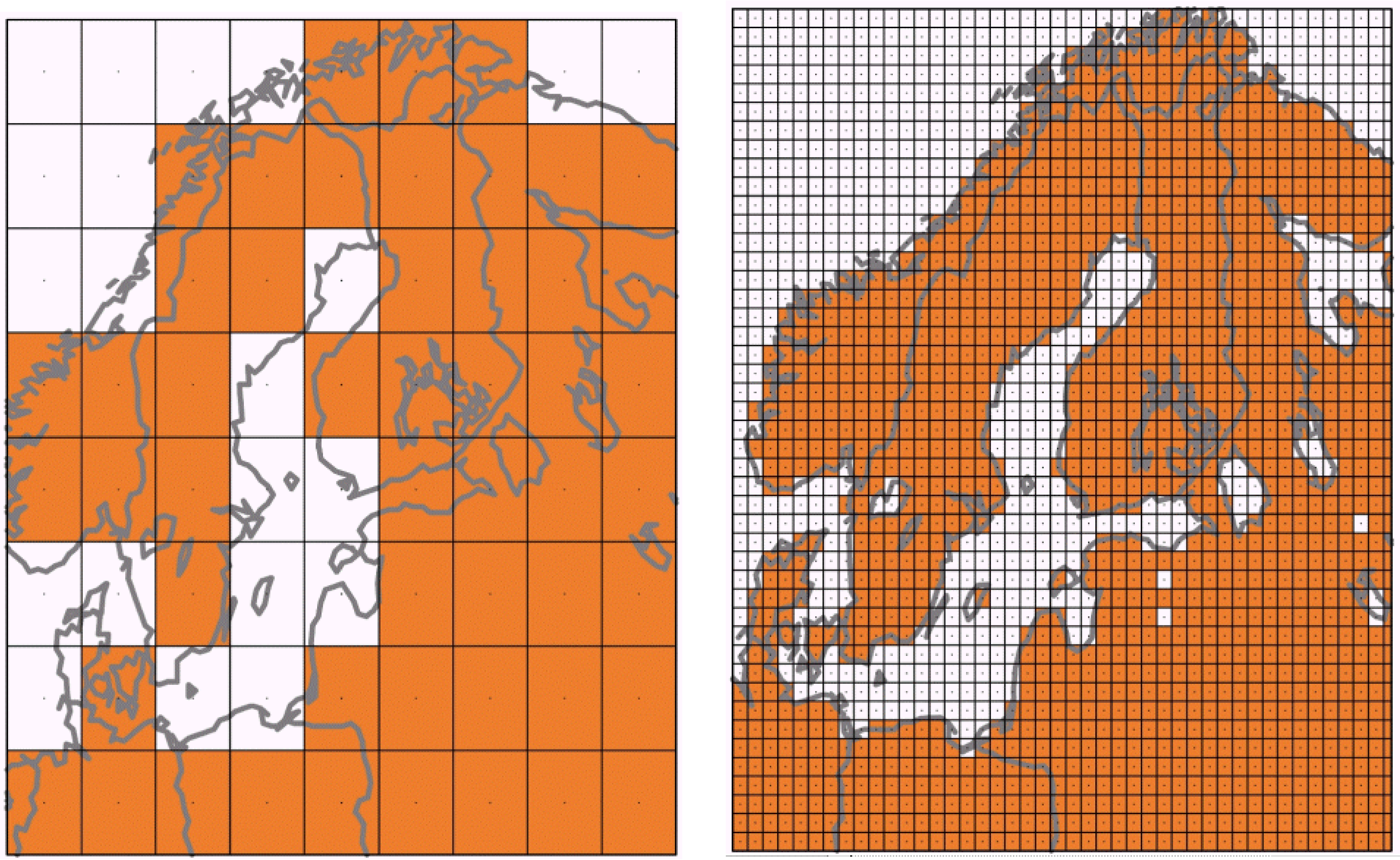
- ***Water demand in agriculture***
- ***Flashfloods***
- ***Heat waves***
- ***Forest fires***
- ***Tourism***
- ...

Meteorological drivers on small scales with assessment of uncertainty

SOURCES OF UNCERTAINTY:

Uncertainty in GCMs – related to:

- *Uncertainty of external forcing*
- *Low spatial resolution – topography, land/ocean boundary, land use,...*
- *Smoothing of extreme values by area averaging*
- *Parametrization of sub-grid processes (clouds, precipitation, heat exchange at surface,*
- *Limited number and accuracy of input data,*
- *Internal variability*

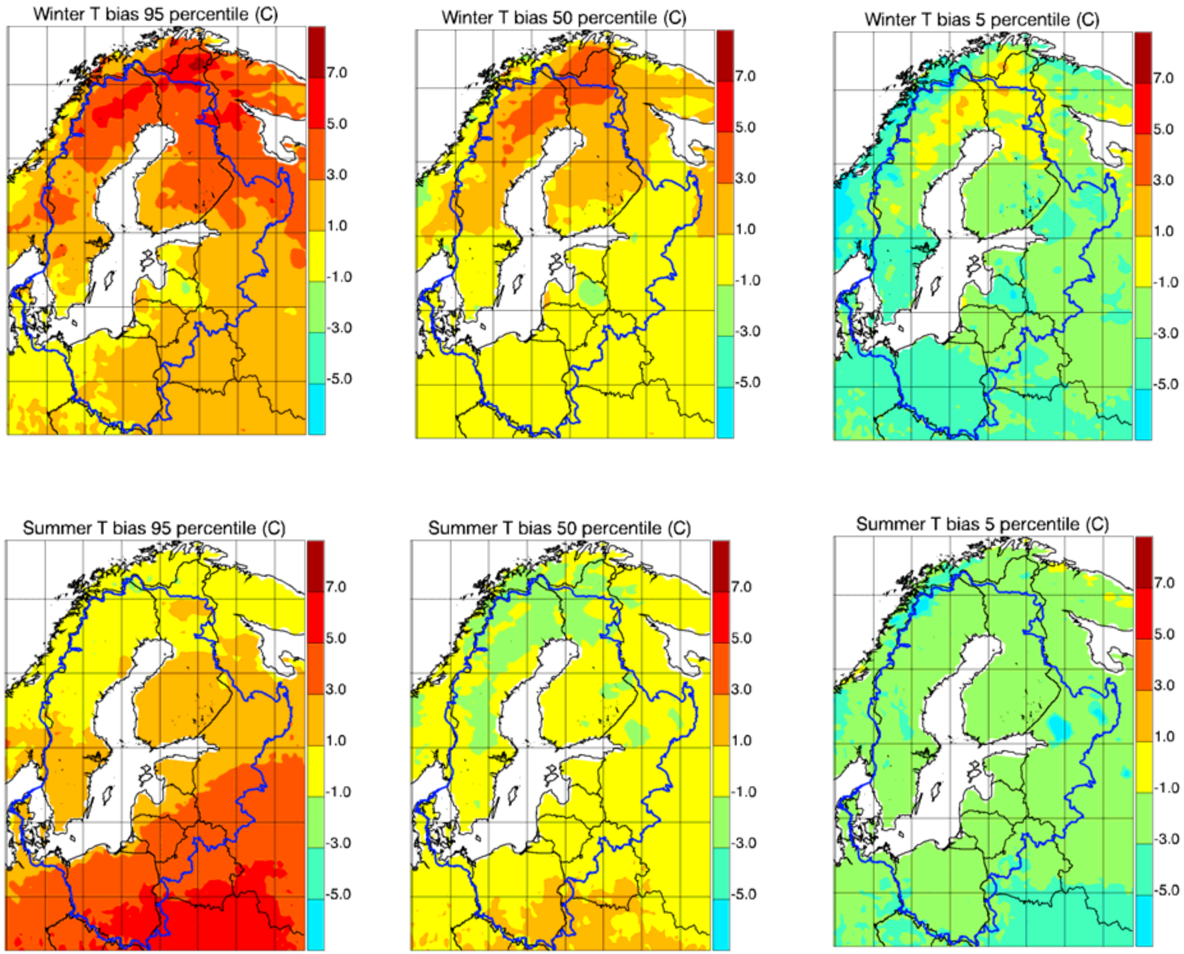


SOURCES OF UNCERTAINTY:

Downscaling method: RCM

- *Still low spatial resolution – topography, land/ocean boundary, land use,...*
- *Parametrization of sub-grid processes (clouds, precipitation, heat exchange at surface,*
- *Smoothing of extreme values by area averaging*
- *The bias inherited from driving GCM,*
- *Internal variability*

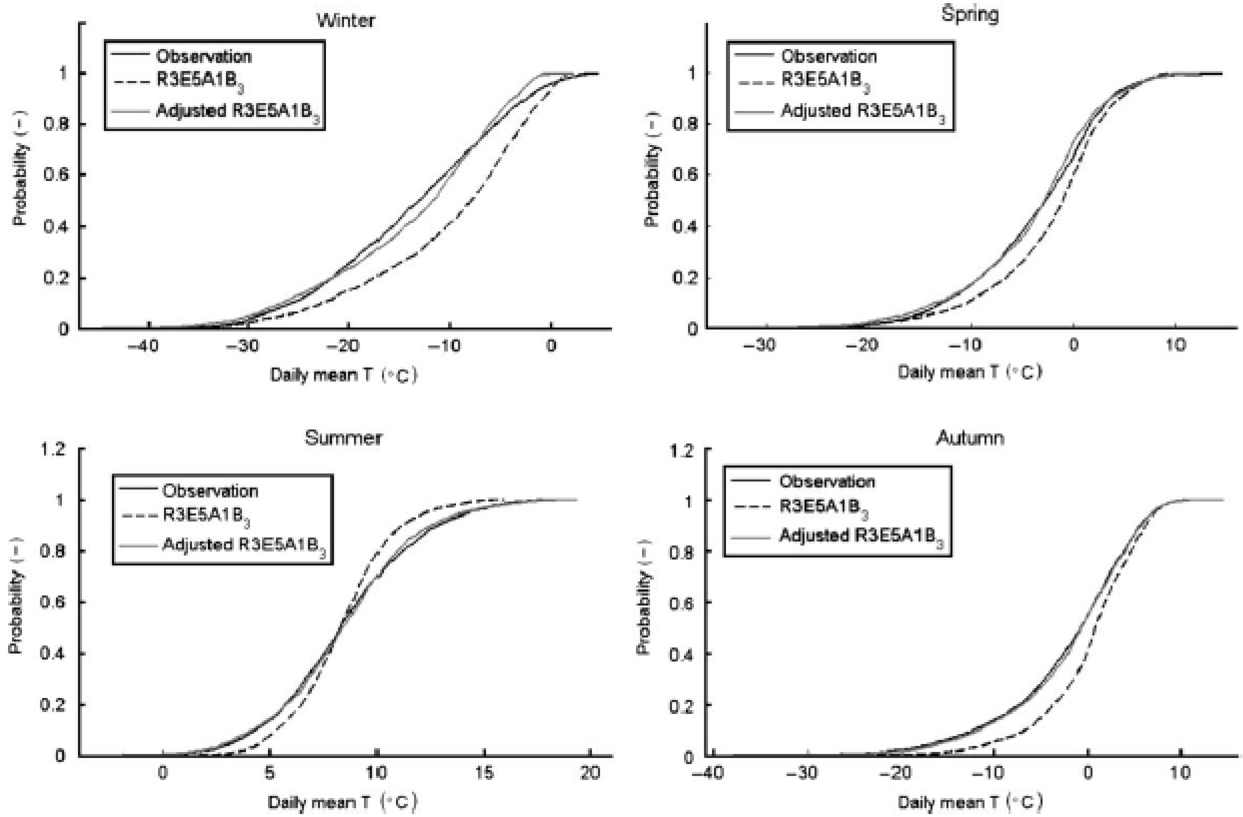
PERFORMANCE OF RCMS IN REPRODUCING THE CLIMATE



Simulated temperature bias (◦C) w.r.t. E-OBS for 1961-2000. The maps show the pointwise smallest (left), median (middle) and largest (right) bias taken from an ensemble of 9 RCMs with lateral boundary conditions taken from ERA40

SKILL OF BIAS CORRECTION

MOS



Yang et al., 2010

Figure 7 | Distribution of daily temperature from observations (1961–1990) and raw R3E5A1B$_3$ and DBS-adjusted R3E5A1B$_3$ projection outputs for the control period for each season in the Stenudden basin.

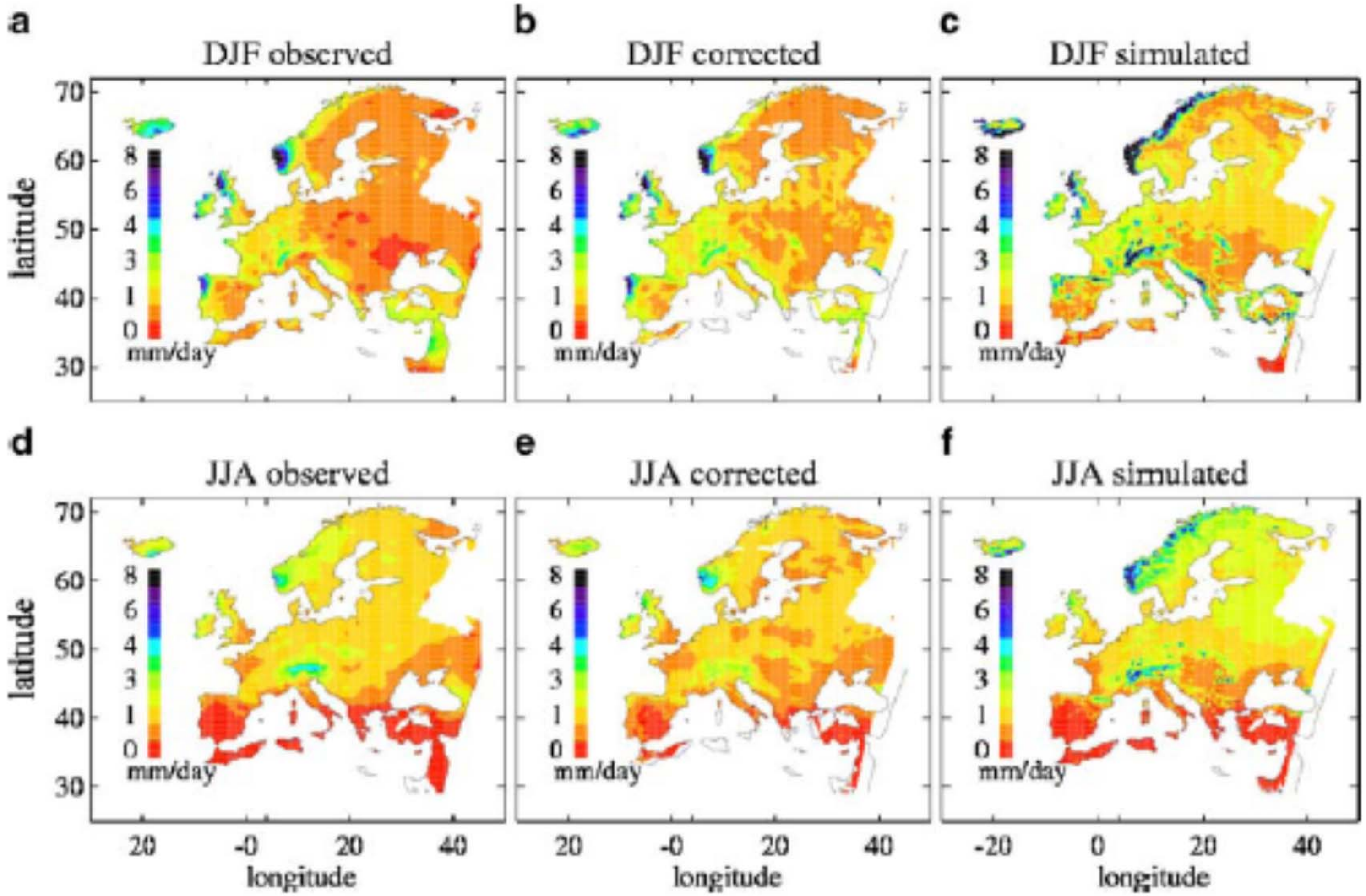


Fig. 4.2-5. Application of bias correction, derived from simulated and observed data from 1961 to 1970, to model data from 1991 to 2000. a Mean observed daily precipitation for winter (DJF) 1991 to 2000, b same as a but for corrected simulated data, c same as a but for uncorrected simulated data. d–f Same as a–c but for summer (JJA) (Piani et al., 2010, Fig.2)

SELECTED SOURCES OF UNCERTAINTY

Effects of temporal resolution	Results of methodological assumption	Drivers uncertainty
Sub-grid processes like cloud formation, convection, precipitation and many others are not explicitly simulated Real coastline and land cover can significantly differ from that in the model. Low resolution flatens the orography influencing not only local climate conditions predicted by the model but also the atmospheric circulation which has an impact on climate in a wider spatial scale.	Effects of nonstationarity of empirical and statistical relationships between large scale predictors and local or point scale predictands. Effects of nonstationarity of biases. Effects of systematic errors in climate models or their groups on ensembles statistics	Uncertainty according to natural drivers of climate variability like solar or volcanic activity. Uncertainty according to anthropogenic drivers of climate change like emissions and concentrations of aerosols and greenhouse gases and changes in land use. Input data to climate models - their quality, precision and limited temporal and spatial distribution.

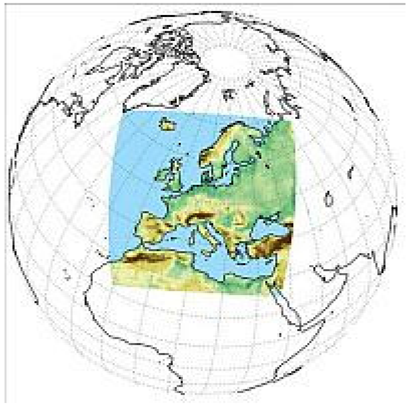
STATION DATA:

23 Polish stations (1951-2005) from IMWM

mean daily temperature

SIMULATIONS :

www.euro-cordex.net



EURO-CORDEX - Coordinated Downscaling Experiment - European Domain

cordex.output.EUR-44.SMHI.CNRM-CERFACS-CNRM-CM5.historical.r1i1p1.RCA4.v1.day.tas

cordex.output.EUR-44.SMHI.NOAA-GFDL-GFDL-ESM2M.historical.r1i1p1.RCA4.v1.day.tas

cordex.output.EUR-44.SMHI.ICHEC-EC-EARTH.historical.r12i1p1.RCA4.v1.day.tas

cordex.output.EUR-44.SMHI.MIROC-MIROC5.historical.r1i1p1.RCA4.v1.day.tas

cordex.output.EUR-44.SMHI.MOHC-HadGEM2-ES.historical.r1i1p1.RCA4.v1.day.tas

PROJECT
DOMAIN
INSTITUTION
DRIVING MODEL
EXPERIMENT
RCM
TEMPORAL RESOLUTION
VARIABLE

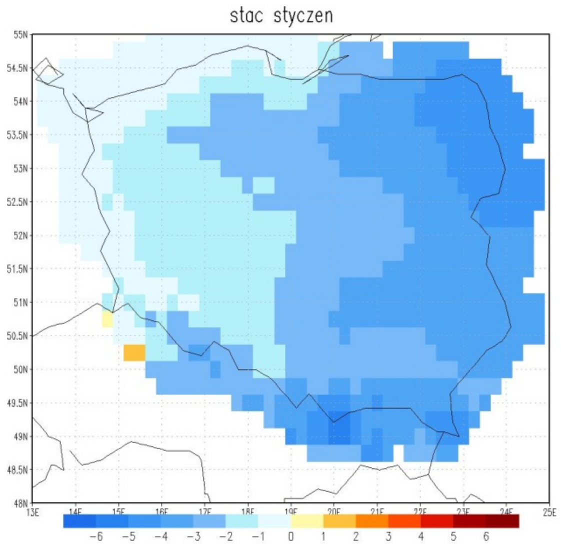
MODEL OUTPUT STATISTICS (MOS)

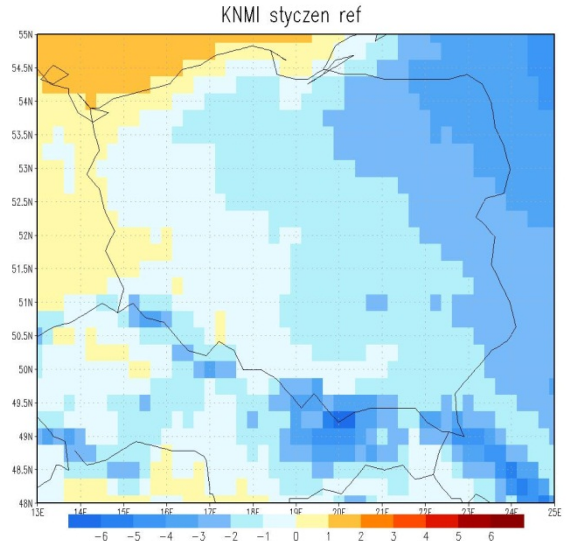
PERTURBATION OF OBSERVED DATA (POD) or DELTA CHANGE (DC)

BIAS CORRECTION or SCALING

Observations

Simulations

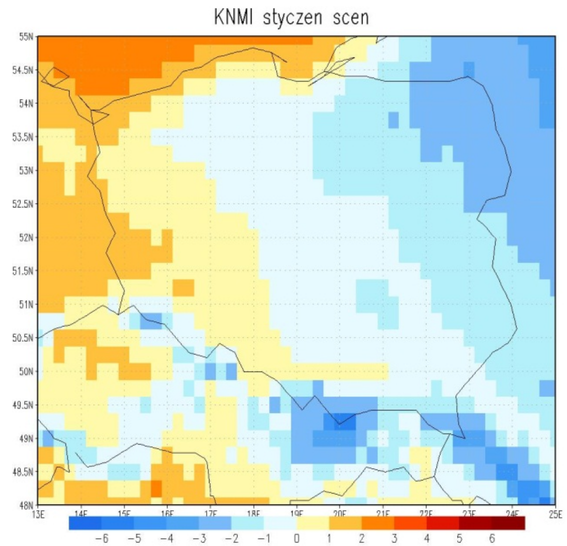




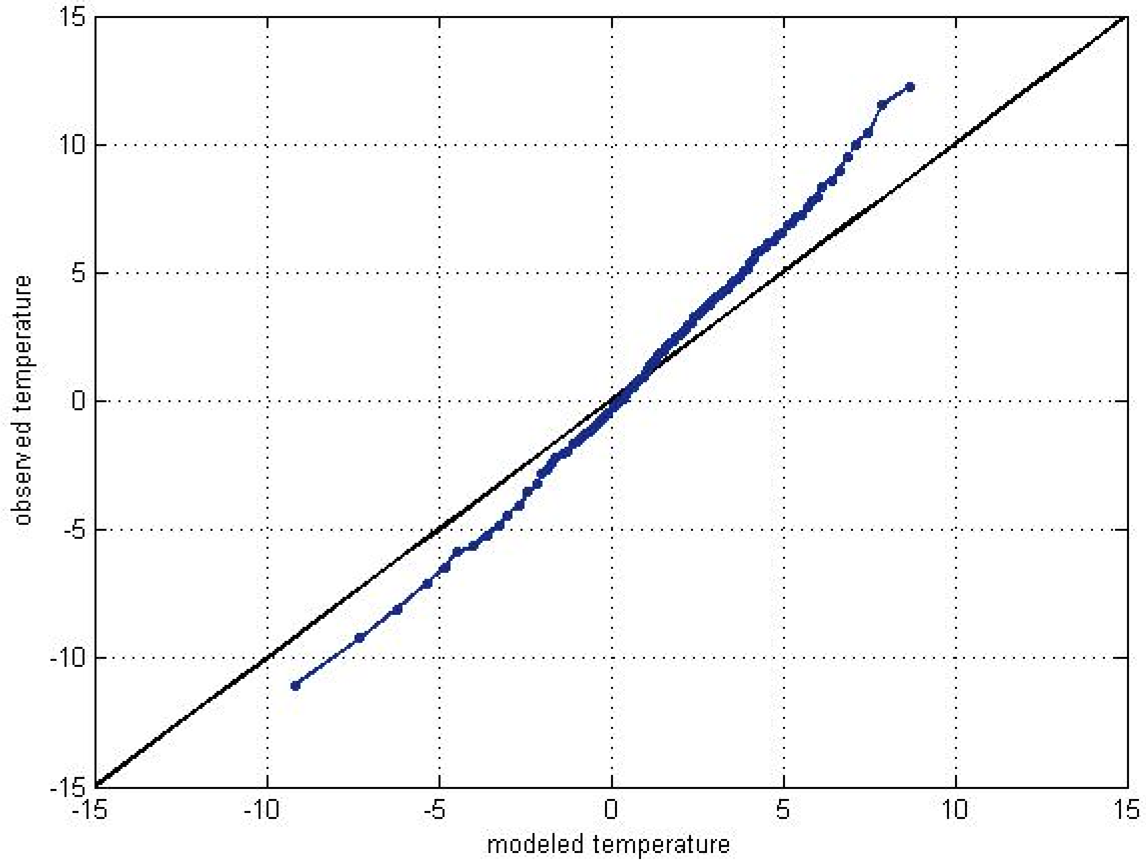
Reference period

Scenario period

?



Q-Q plot



15
10
5
0
-5
-10
-15
-15
-10
-5
0
5
10
15
observed temperature
modeled temperature

Methods of projection:

- *simple bias correction,*
- *distribution based bias correction (Yang et al., 2010; Piani et al., 2010),*
- *simple delta change,*
- *distribution based delta change.*

EVALUATION OF CORRECTIONS:

Data are divided into two periods:

- ***reference period 1951-1975***
- ***evaluation period 1981-2005***

On the base of observations in reference period and simulations in both periods the projections for evaluation period are calculated using four mentioned methods

In the evaluation period the differences between observations and simulations are compared with differences between observations and projections.

IMPROVEMENT

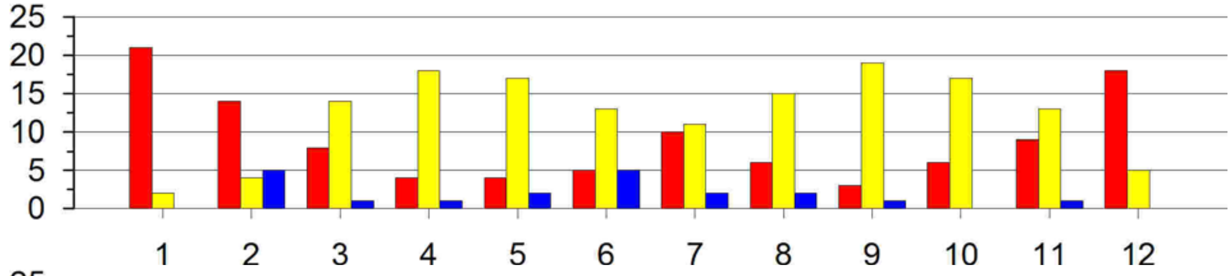
NO CHANGE

WORSENING

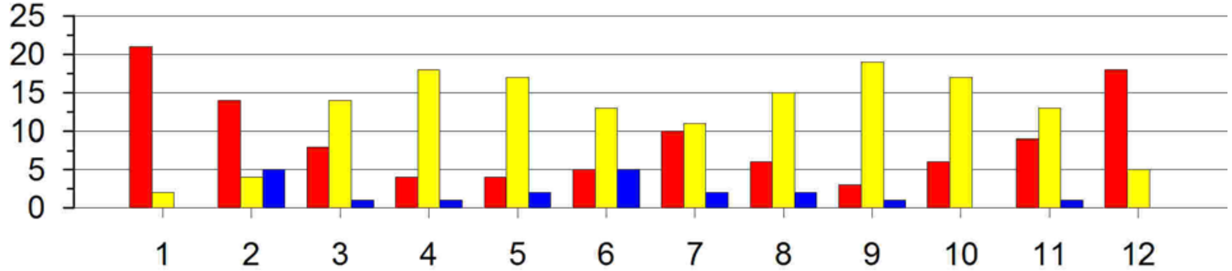
MEAN

MOHC

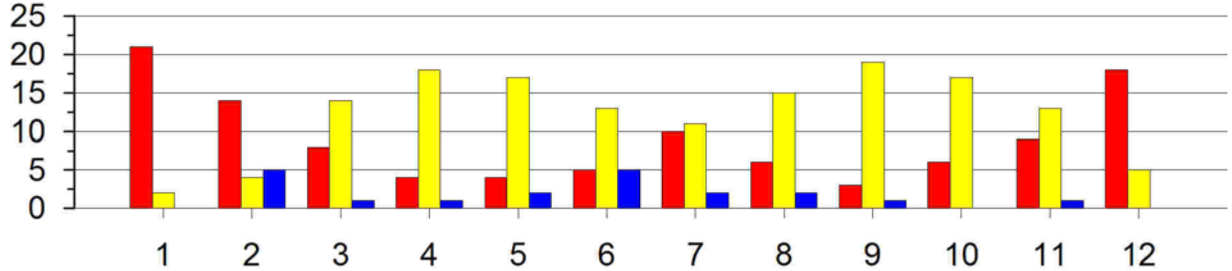
Simple bias



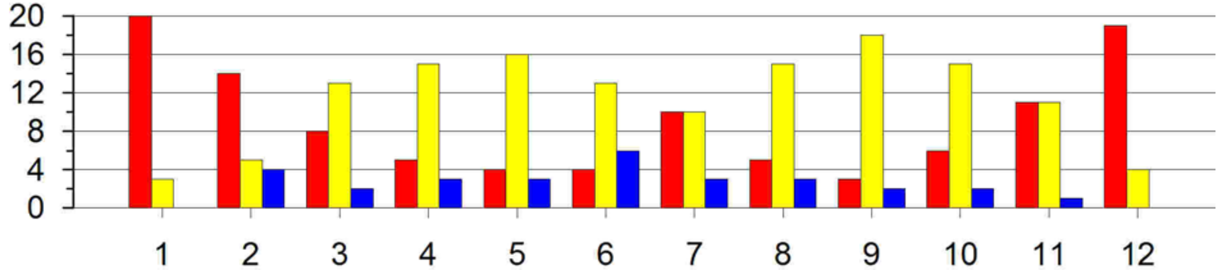
Distribution based bias



Simple delta change

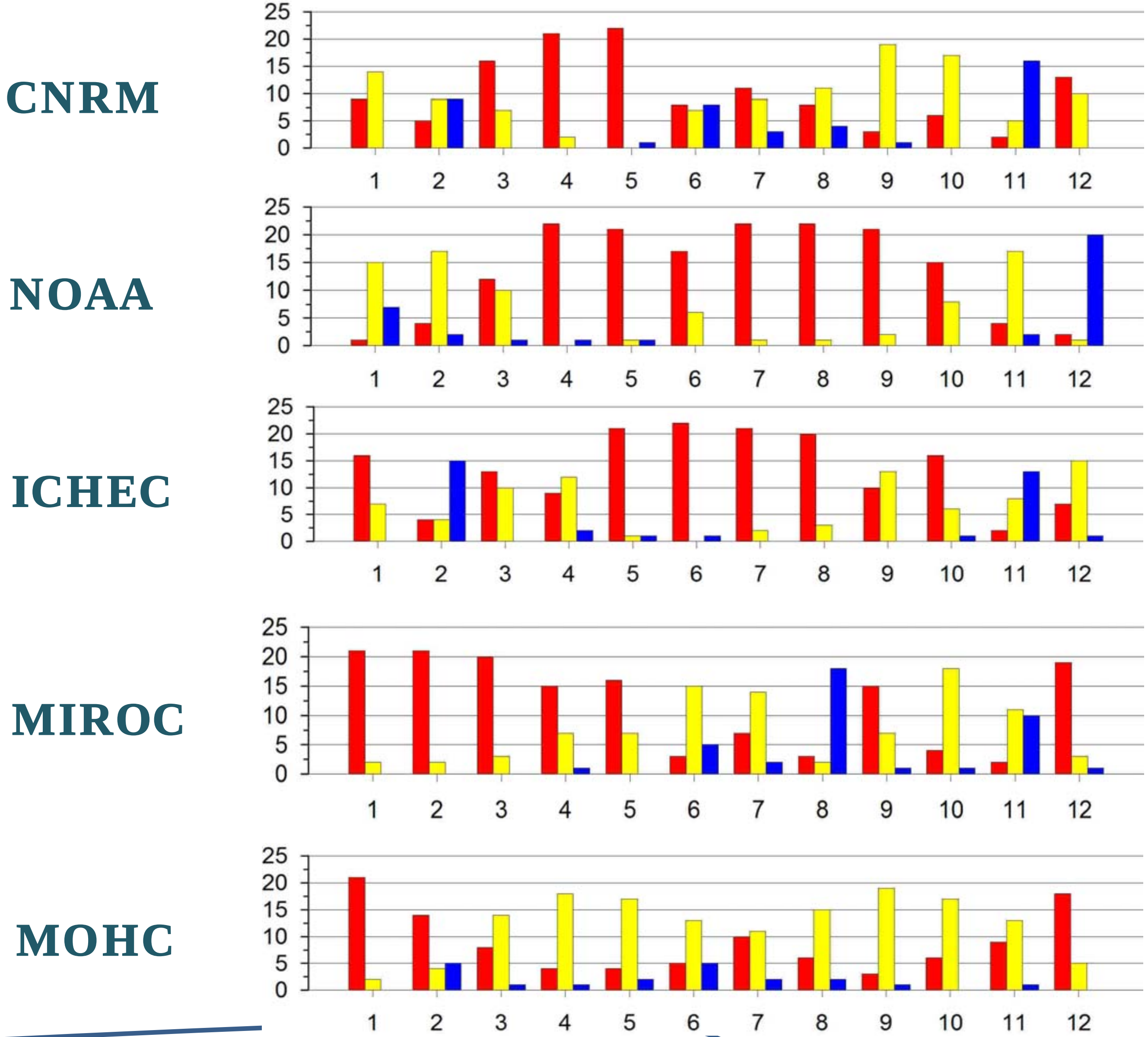


Distribution based delta change



MEAN

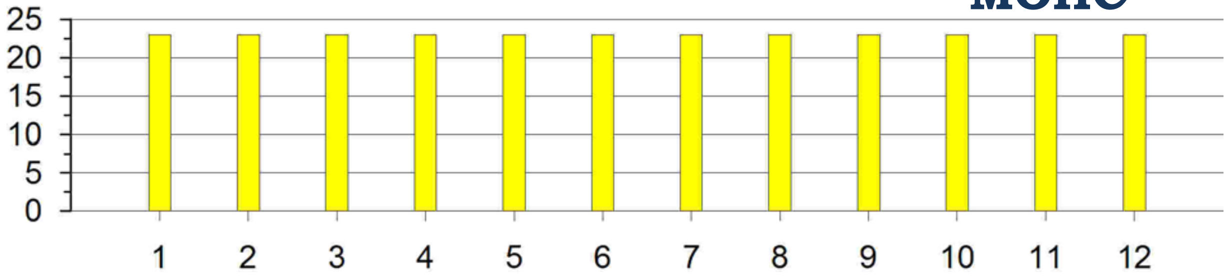
Distribution based bias



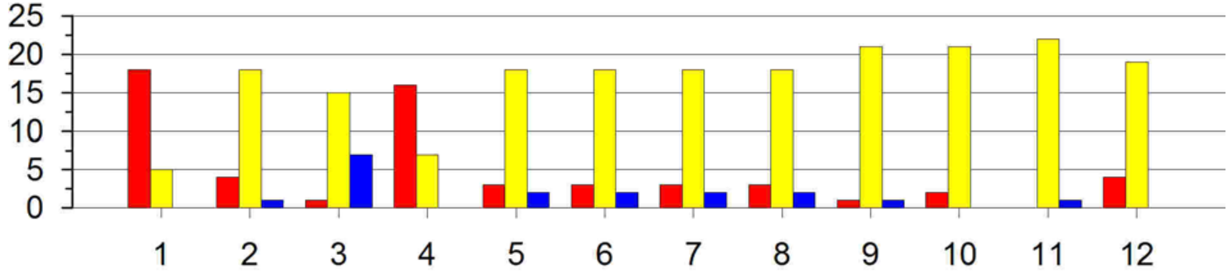
STANDARD DEVIATION

MOHC

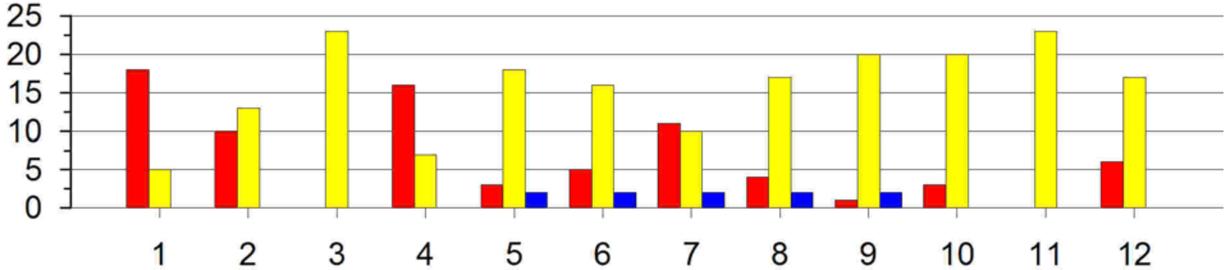
Simple bias



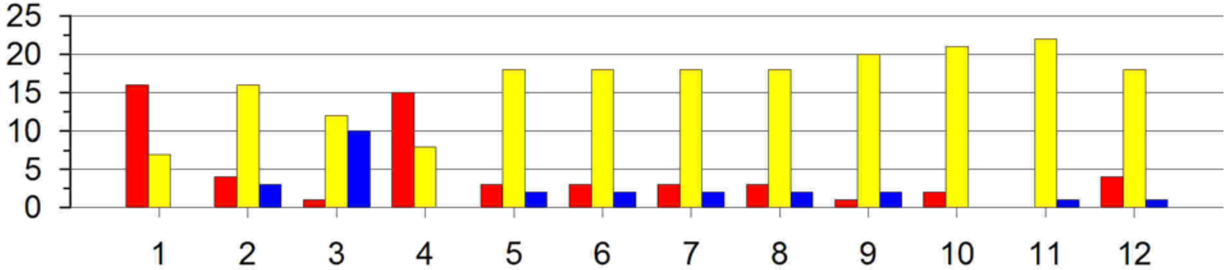
Distribution based bias



Simple delta change



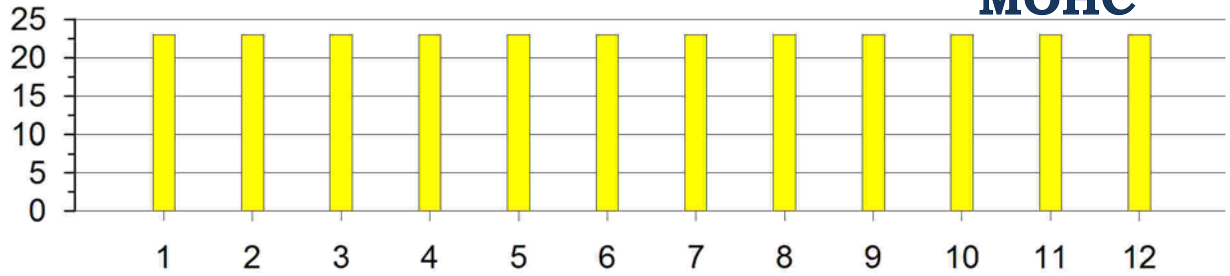
Distribution based delta change



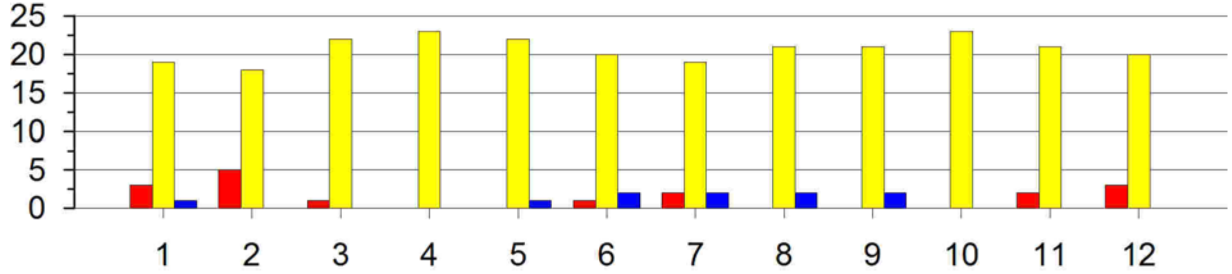
SKEWNESS

MOHC

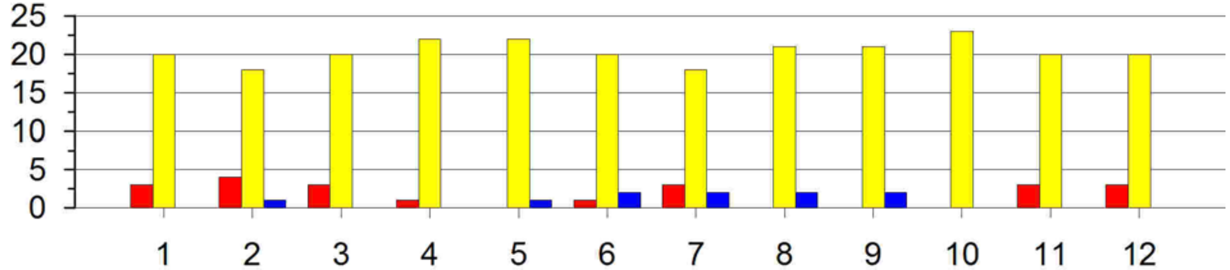
Simple bias



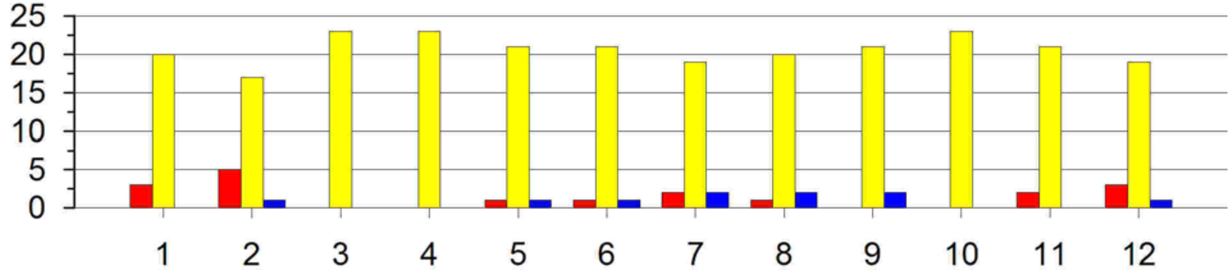
Distribution based bias



Simple delta change



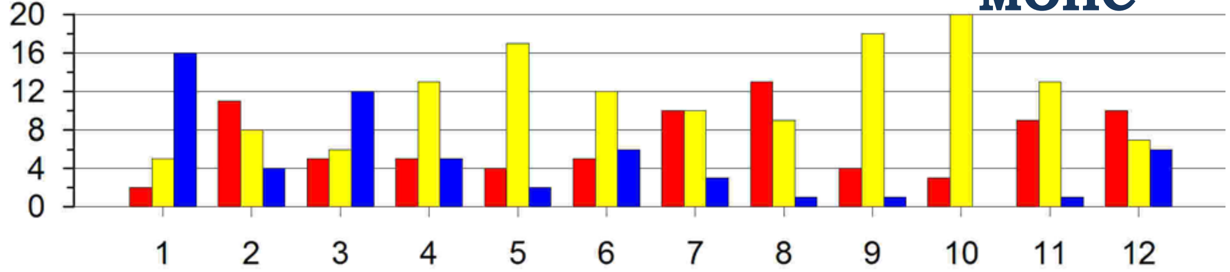
Distribution based delta change



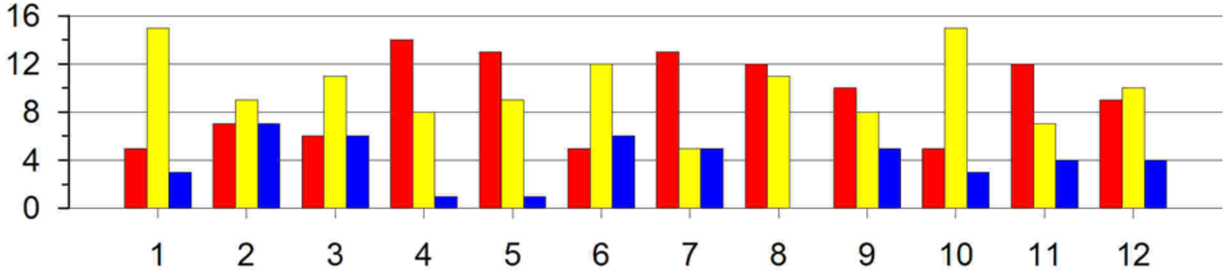
90TH PERCENTILE

MOHC

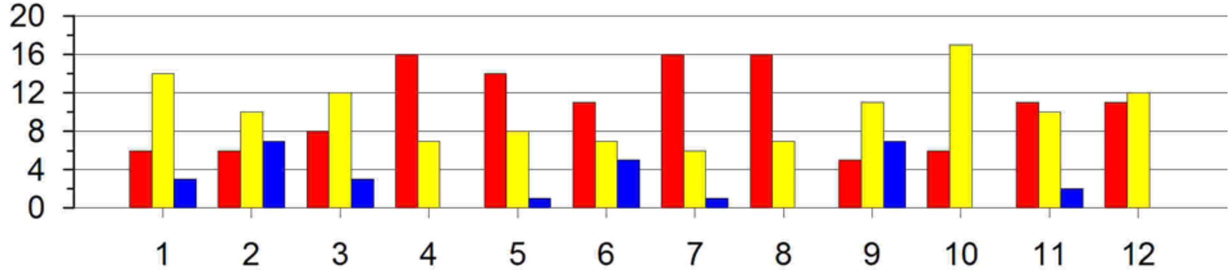
Simple bias



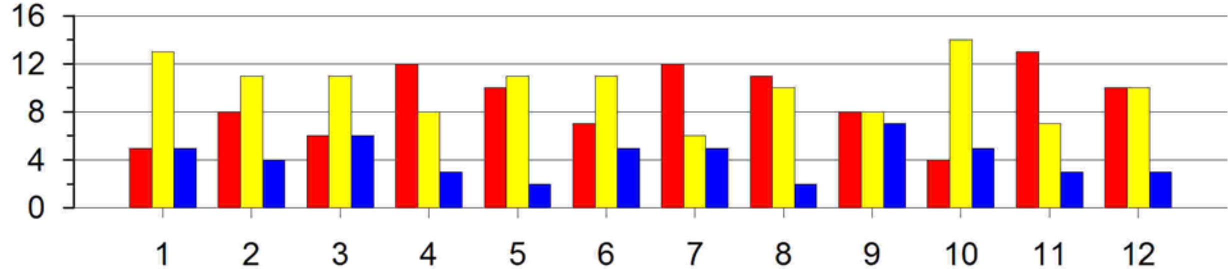
Distribution based bias



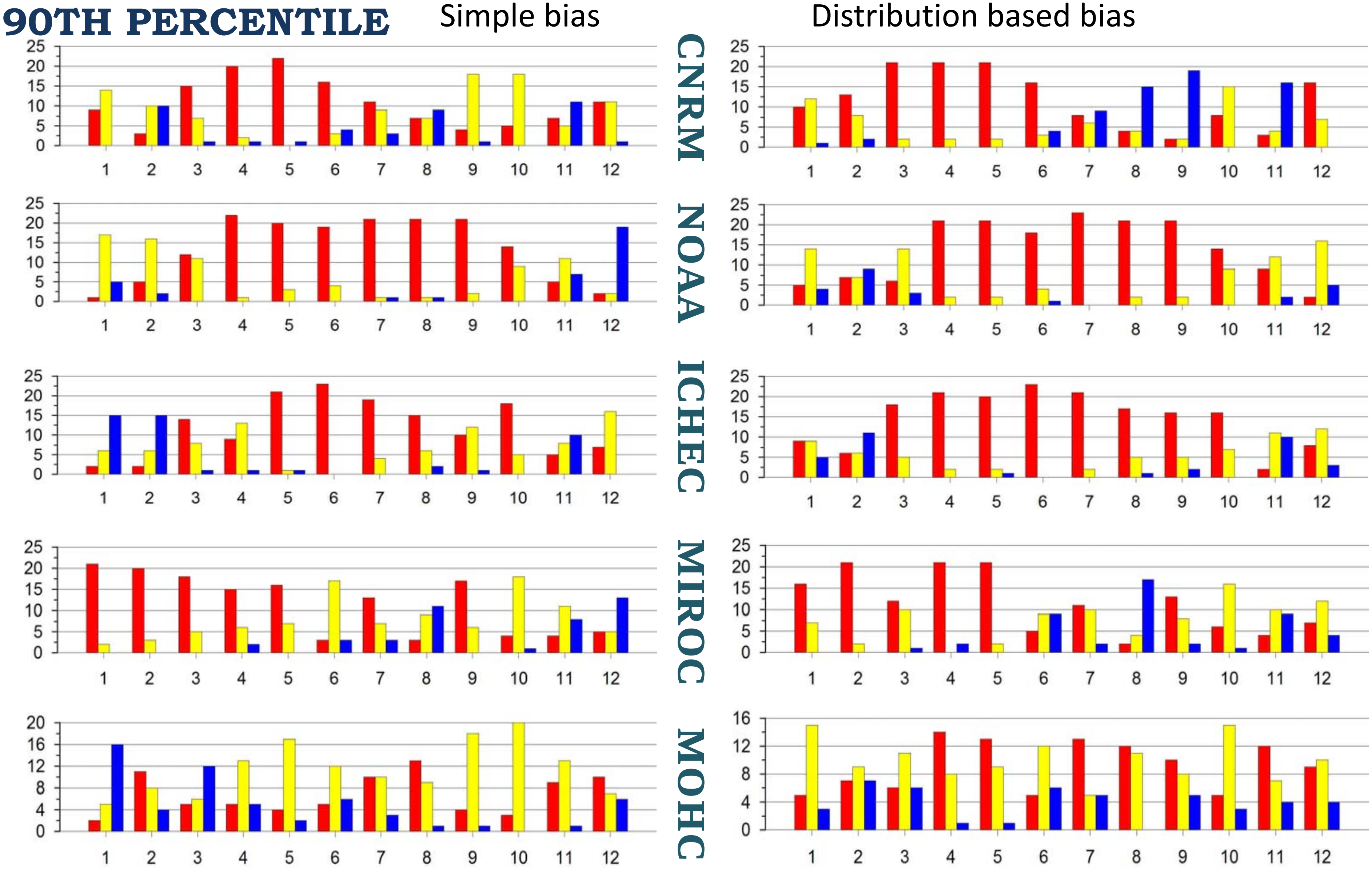
Simple delta change



Distribution based delta change

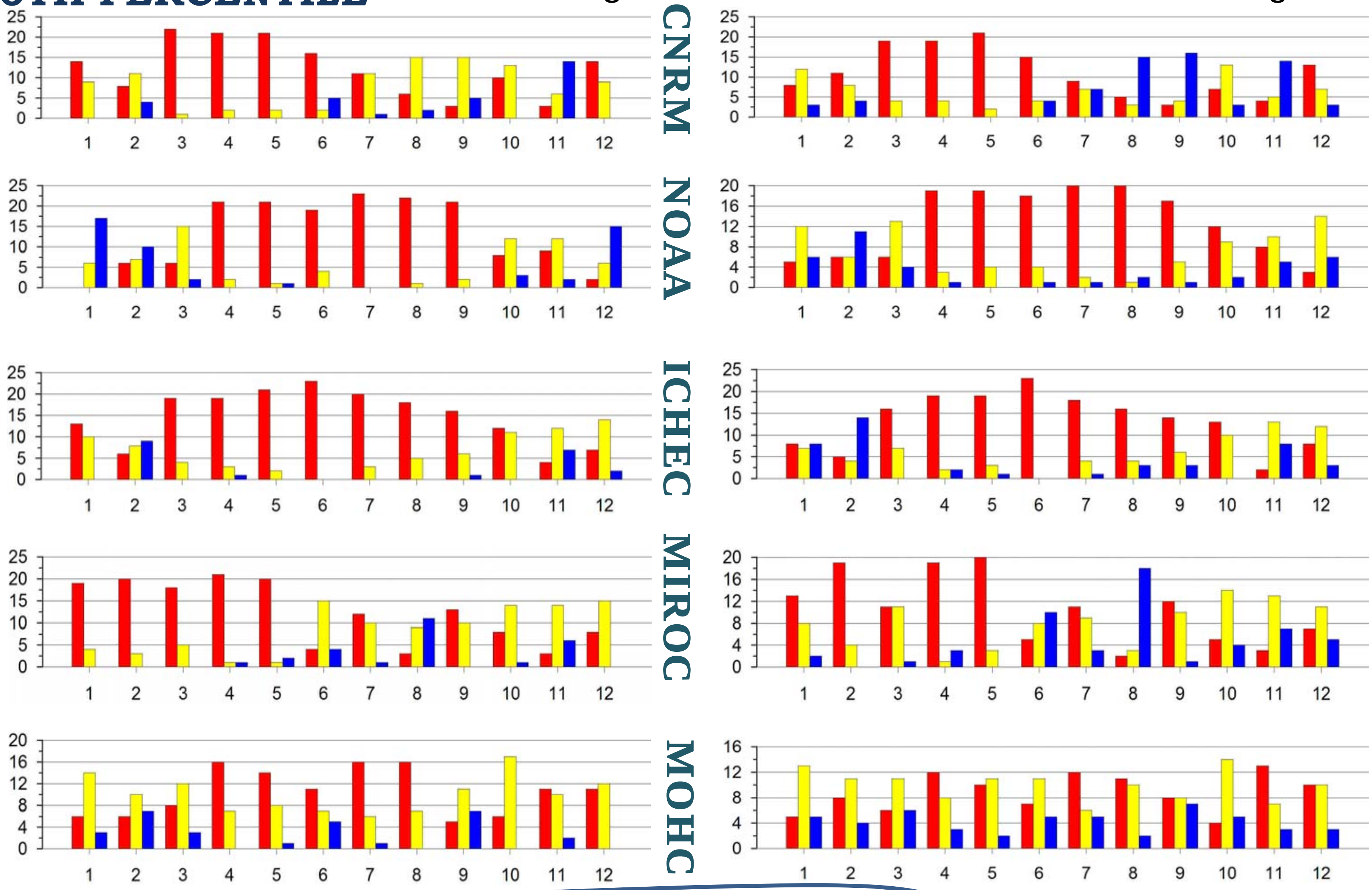


90TH PERCENTILE



90TH PERCENTILE

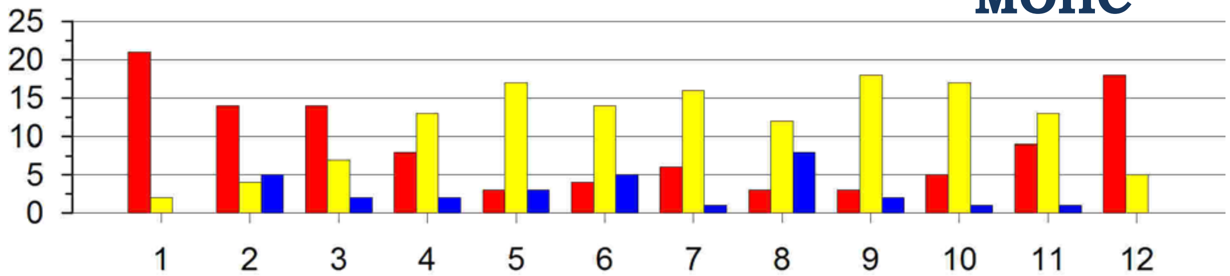
Delta change | Distribution based delta change



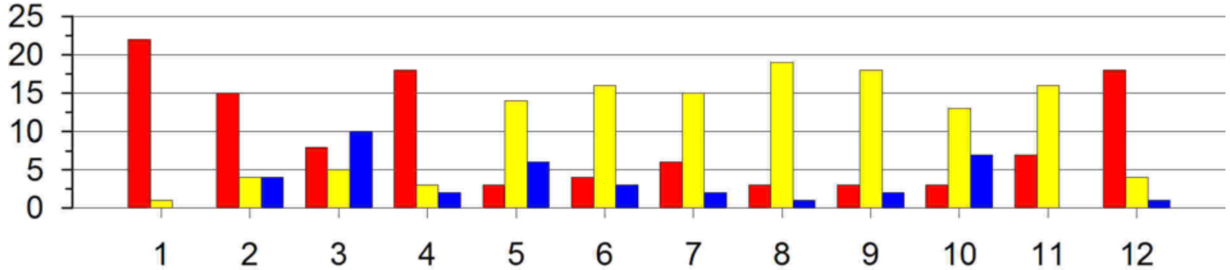
10TH PERCENTILE

MOHC

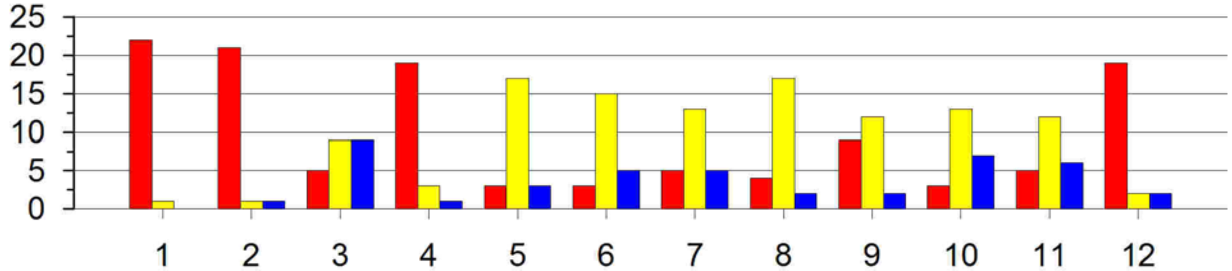
Simple bias



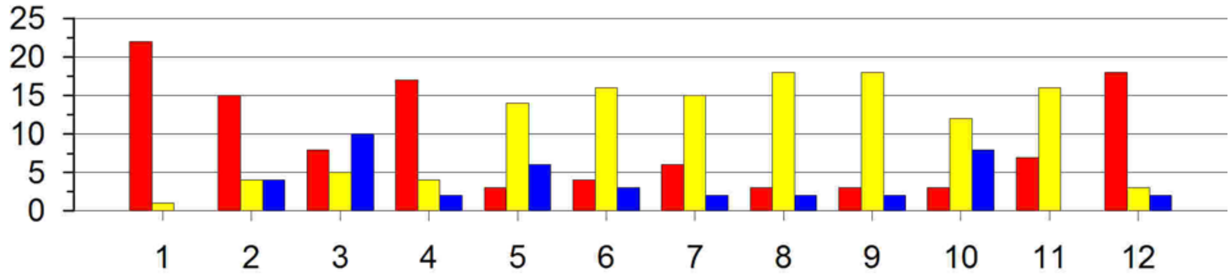
Distribution based bias



Simple delta change



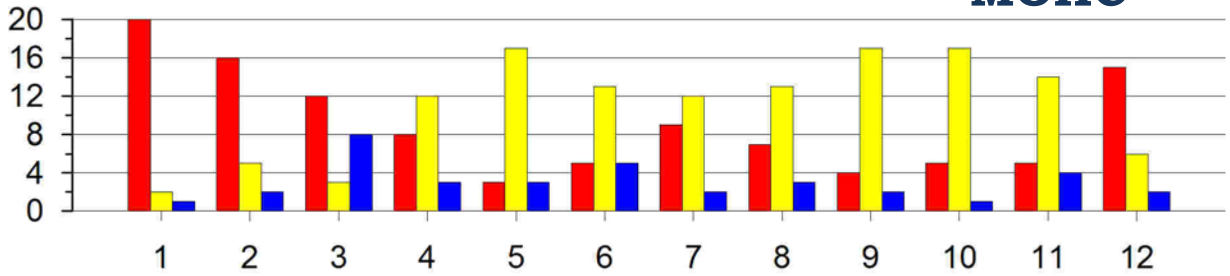
Distribution based delta change



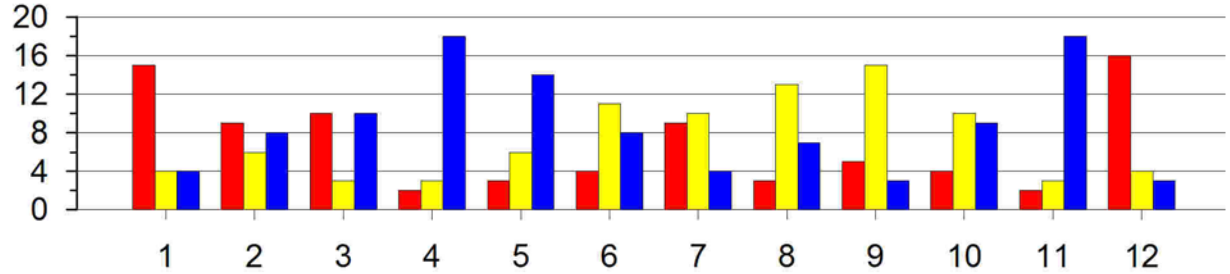
1ST PERCENTILE

MOHC

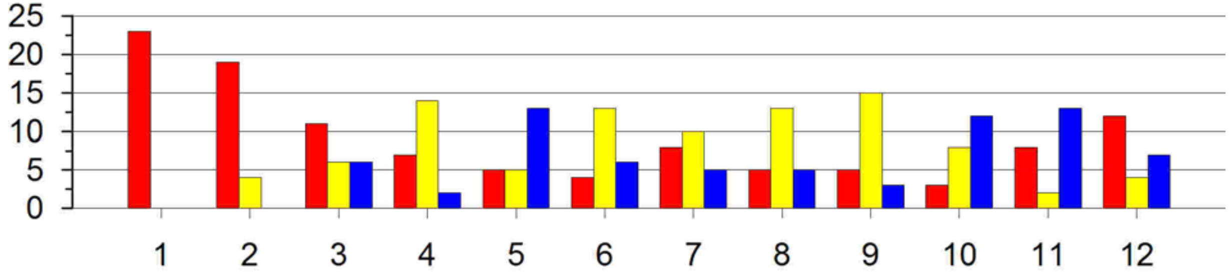
Simple bias



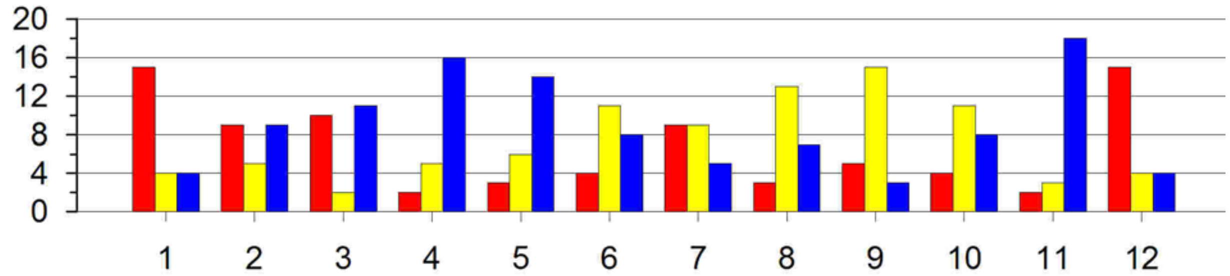
Distribution based bias



Simple delta change

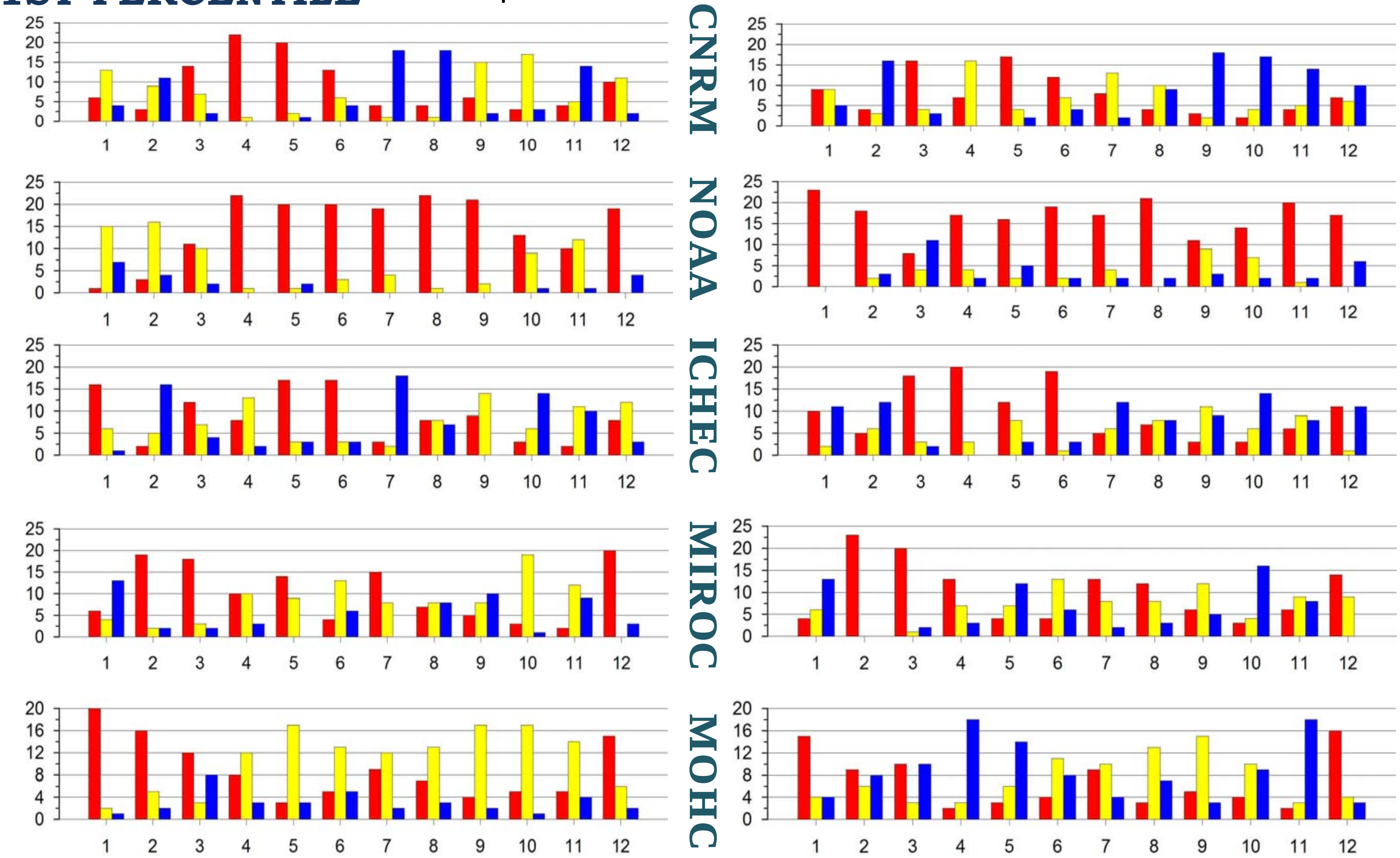


Distribution based delta change



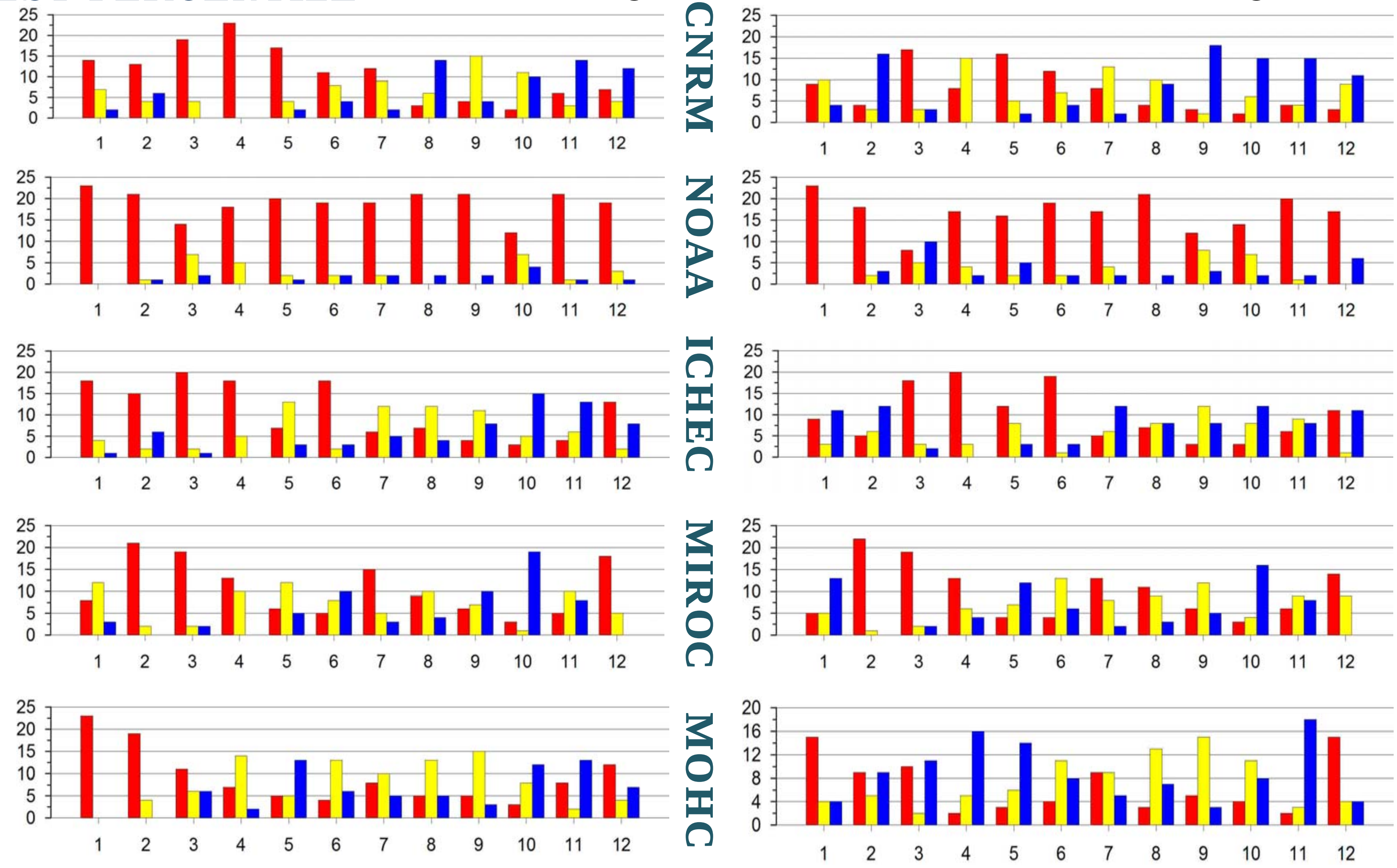
1ST PERCENTILE

Simple bias | Distribution based bias



1ST PERCENTILE

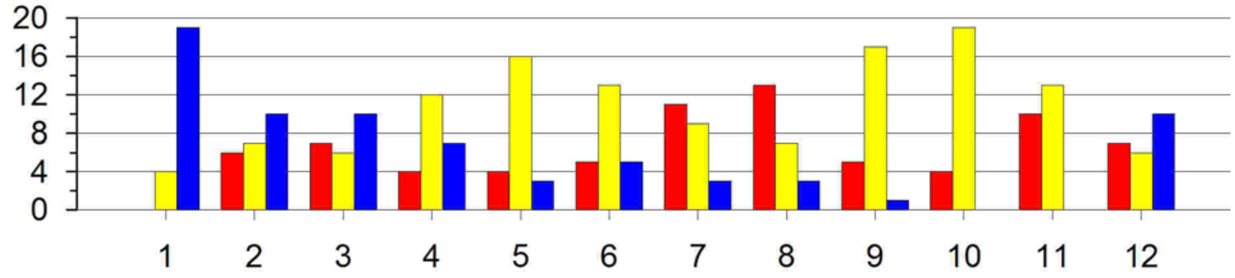
Delta change | Distribution based delta change



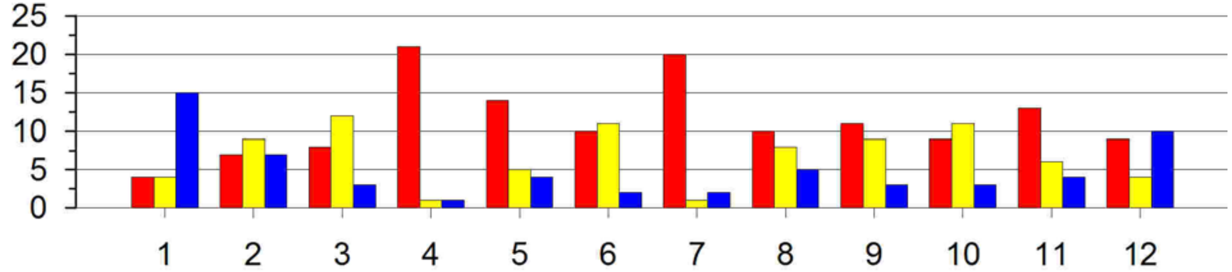
99TH PERCENTILE

MOHC

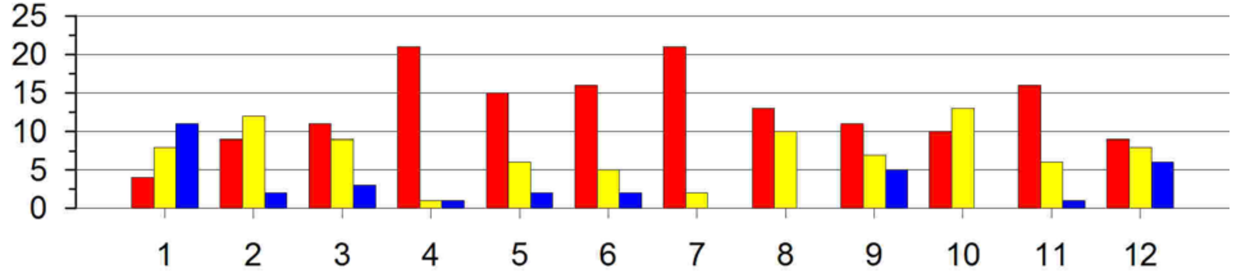
Simple bias



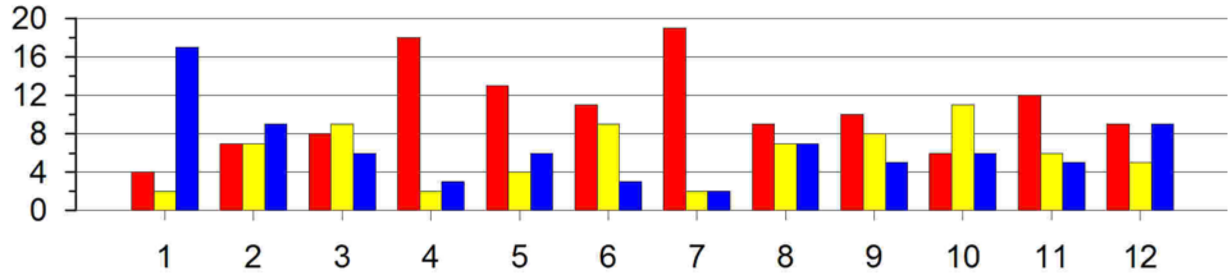
Distribution based bias



Simple delta change



Distribution based delta change



SUMMARY

1. MEAN

- There is a strong improvement in the case of mean monthly temperature, however in some cases the quality of projection decreases
- There is no big difference between methods

2. STANDARD DEVIATION and SKEWNESS

- There is no improvement in the case of temperature

SUMMARY cd.

3. „moderate" EXTREMES

- There is some improvement in the case of moderate extremes (90th and 10th percentiles), however in some cases the quality of projection decreases
- Distribution based methods do not perform better than simple bias correction or delta change

SUMMARY cd.

4. „extreme" EXTREMES

- There is rather small improvement in the case of extreme extremes (99th and 1st percentiles), however in numerous cases the quality of projection decreases
- Distribution based methods perform weaker than simple bias correction or delta change

Bias nonstationarity

Correcting climate models implicitly assumes stationarity of the correction function. Generally, biases are relatively stable, and bias correction on average improves climate scenarios.

However Maraun (2012) has shown that the temperature bias correction can deteriorate the future simulation for the Barents Sea, White Sea and the Gulf of Bottnia during winter and spring.

Nonstationarity of bias can occur due to bias sensitivity of cloud cover, soil moisture, snow cover or sea ice.

Maraun, 2012, GRL, V. 39, L06706

Natural variability

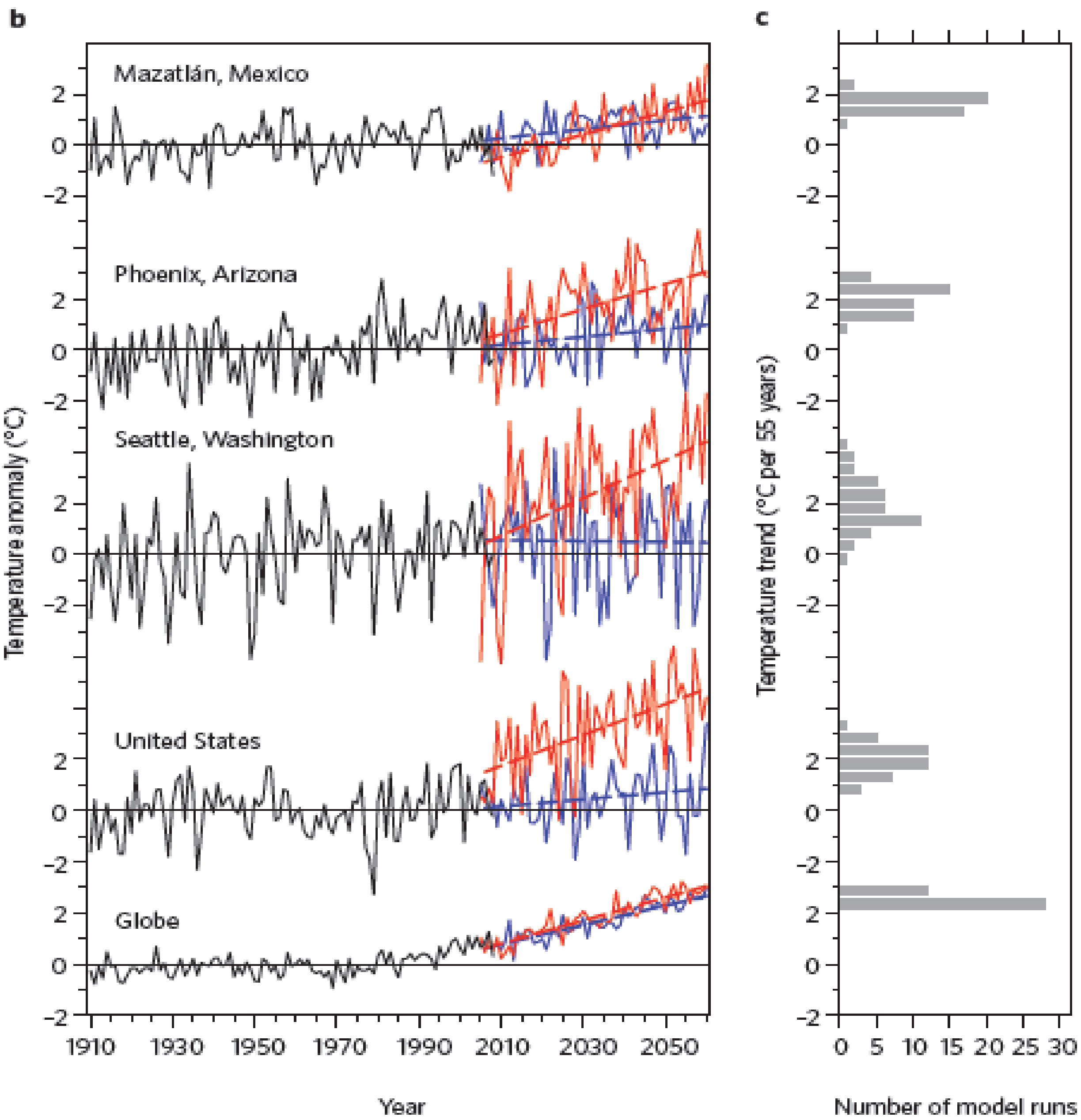
Bias or factors of change are calculated from limited samples, so there are only estimated. The real values can differ from the estimators, the difference may be higher when the sample is smaller. It can explain relatively high frequency of improvements in the case of mean values, not very bad situation in the case of moderate extremes (90th and 10th percentiles of distribution) and low frequency of improvements with many cases of worsening for extreme percentiles (1st and 99th).

Uncertainty in climate projections is mainly due to :

- ***emissions-scenario uncertainty,***
- ***model-response uncertainty,***
- ***natural variability.***

The uncertainty due to natural variability can not be reduced in the future, so it is crucial to assess the amplitude of natural variability in the area of interest.
There was no such assessments for the Baltic Sea region, but Deser et al. (2012) analyse this issue for North America.
Some results can be usefull for other locations, like increase of natural variability with decrease of scale, and higher natural variability in middle latitudes comparing with low and high latitudes.

Deser et al., 2012, DOI: 10.1038/NCLIMATE1562



b. DJF temperature anomaly time series for selected cities, the contiguous United States and the globe (land areas only). Black curves show observed records from 1910 to 2008 (minus the long-term mean); red and blue curves show model projections for 2005–2060 from the realizations with the largest and smallest future trends, respectively, for each location or region. Dashed red and blue lines show the best-fit linear trends to the red and blue curves, respectively **c**, Distribution of projected DJF temperature trends (2005–2060) across the 40 ensemble members at the locations shown in panel **b**.

Deser et al., 2012, DOI: 10.1038/NCLIMATE1562

The work was supported by grant 2012/05/B/ST10/00945 founded by Polish National Science