

2011 NARCCAP Users' Meeting, Boulder, Colorado

**Bias-adjusted CRCM-CGCM3
simulation and its application in the
SWAT modeling of lower Missouri
River Basin**

Lei Qiao, Zaitao Pan and Robert Herrmann
Department of Earth and Atmospheric Sciences
Saint Louis University

Outline

- Overview of climate modes used by NARCCAP
- Biases and bias corrections to the CRCM-CGCM3 simulations
- SWAT modeling of lower Missouri River basin with CRCM-CGCM3 data

Atmosphere-Ocean General Circulation Models (AOGCMs)

- the Canadian Global Climate Model version 3 (CGCM3, T47 spatial resolution, [\[Flato 2005\]](#));
- the NCAR Community Climate Model version 3 (CCSM3, [\[Collins 2006\]](#));
- the Geophysical Fluid Dynamics Laboratory (GFDL) Climate Model version 2.1 (CM2.1, [\[GFDL 2004\]](#));
- the United Kingdom (UK) Hadley Centre Climate Model version 3 (HadCM3, [\[Gordon 2000\]](#), [\[Pope 2000\]](#)).

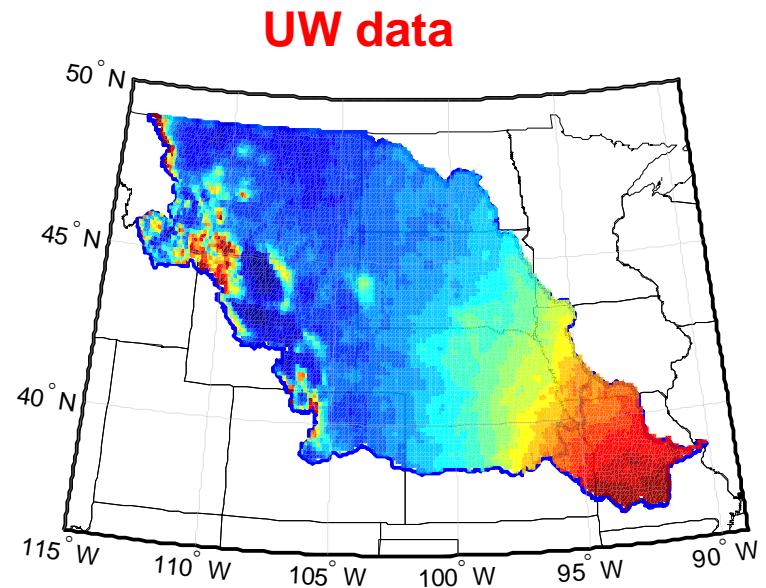
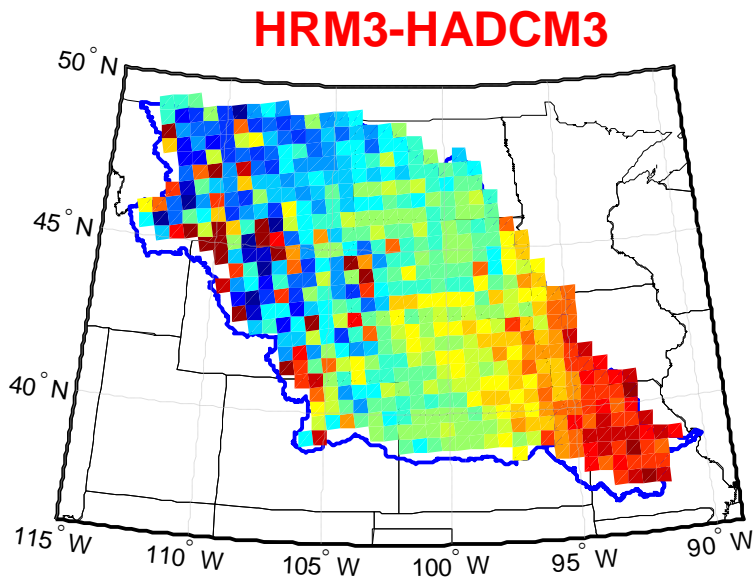
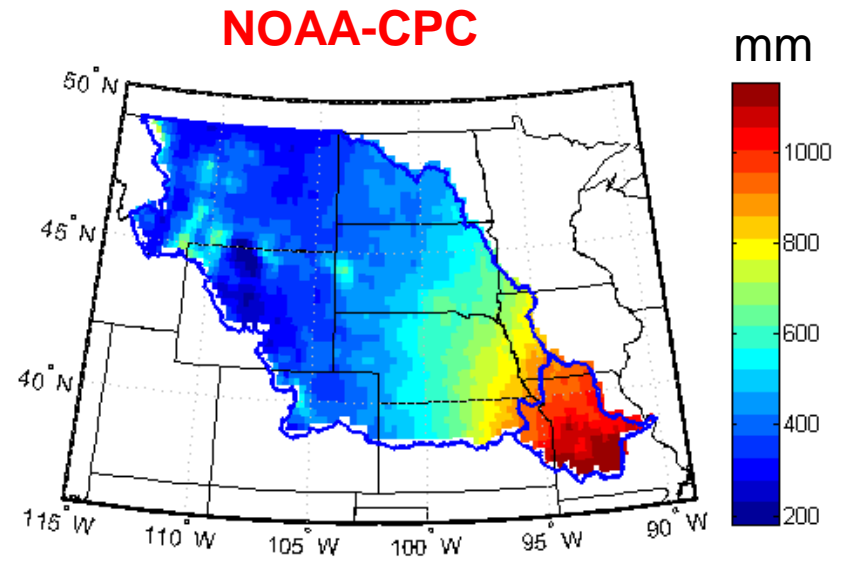
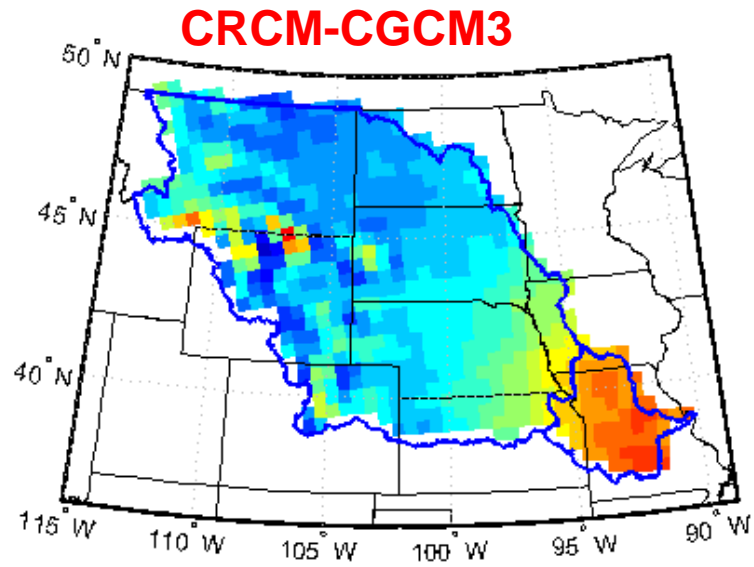
Regional Climate Models (RCMs)

- European PRUDENCE program (HadRM3 and RegCM)
- Canadian Regional Climate Model (CRCM)
- NCEP regional spectral model (RSM)
- PSU/NCAR mesoscale model (MM5)
- Weather Research and Forecasting model (WRF)

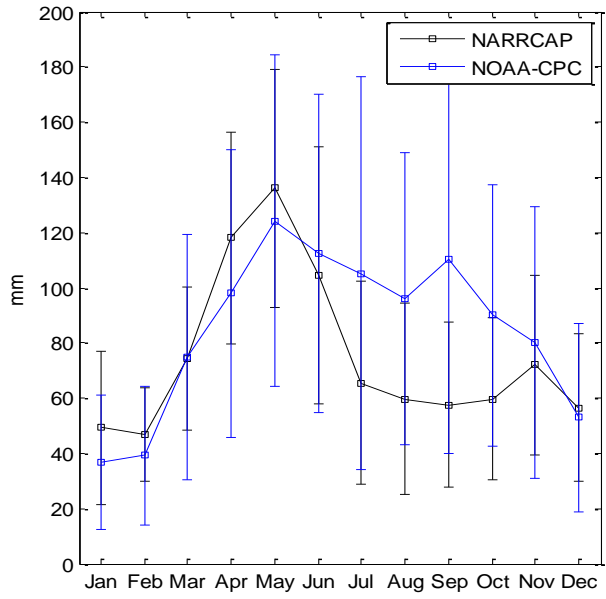
Objective

- ❖ Examine and correct the biases between observations and the NARCCAP data; Reduce the uncertainty in the climate change impacts on the hydrology processes of the lower Missouri River basin.
- ❖ Mainly working for the CRCM-CGCM3 data

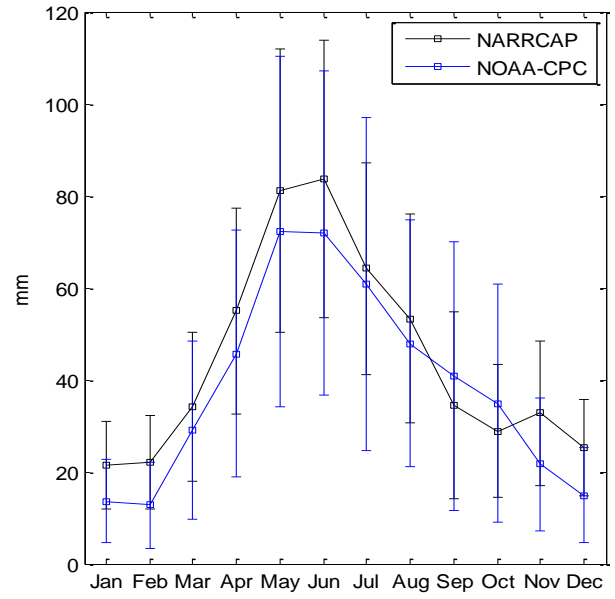
1. 1 Bias in precipitation (1968-1998)



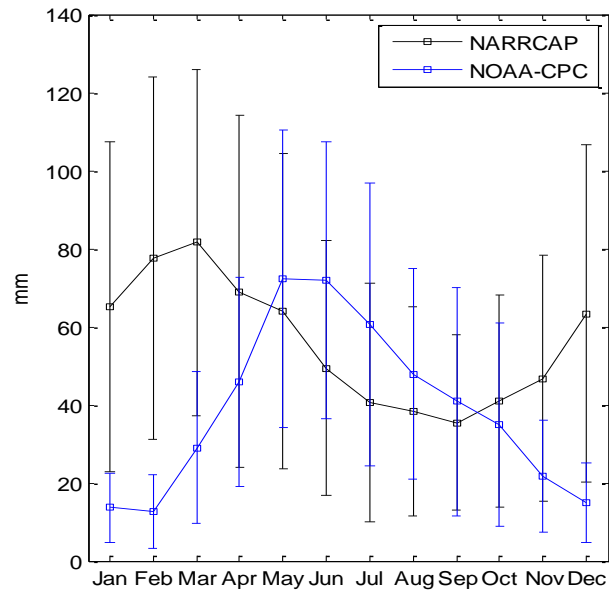
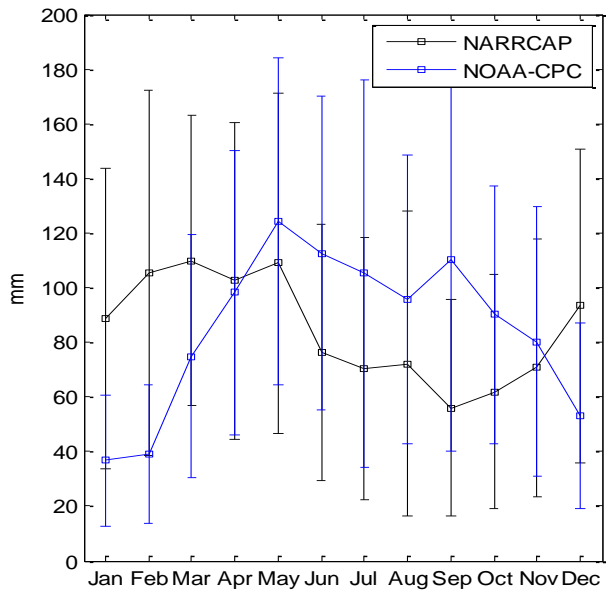
Lower MoRB



Upper MoRB



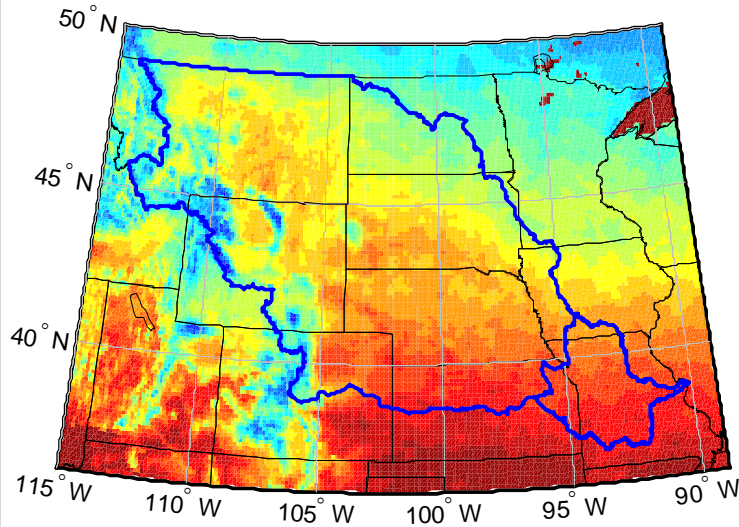
**CRCM-
CGCM3**



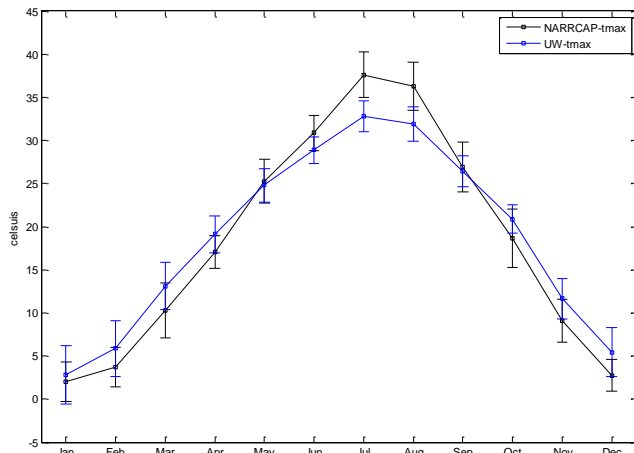
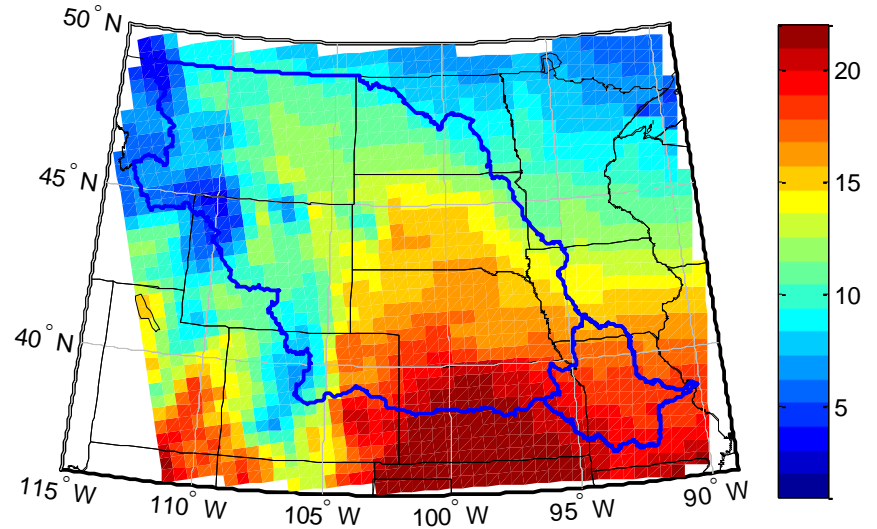
**HRM3-
HADCM3**

1.2 Bias in maximum temperature

UW data



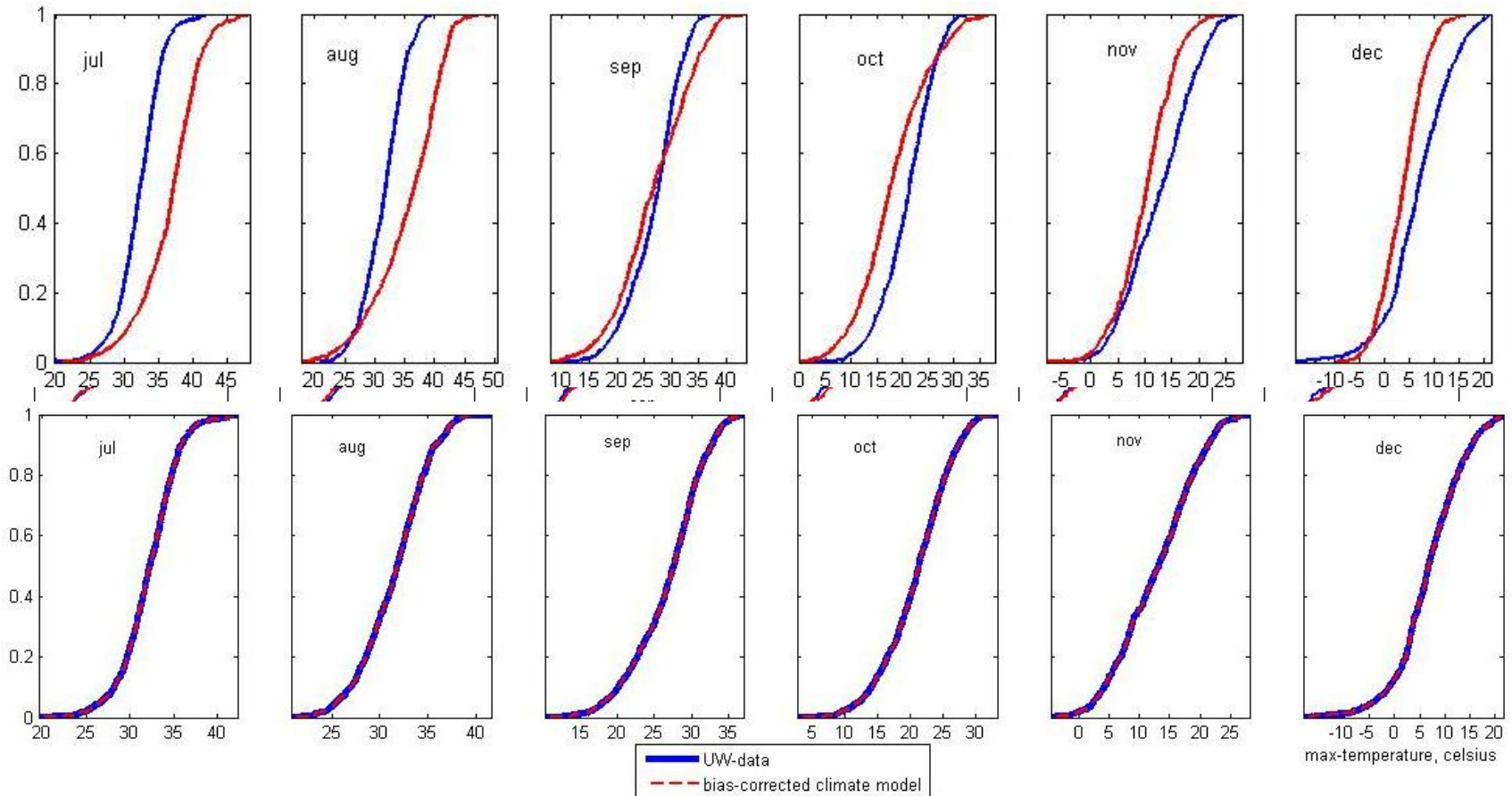
CRCM-CGCM3



Better agreement spatially and temporally for temperature than for precipitation.

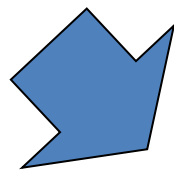
2. Bias correction

The distribution mapping approach (Wood et al., 2002 and 2004; Ines and Hansen, 2006; Christensen and Lettenmaier, 2007; Sharma et al., 2007)

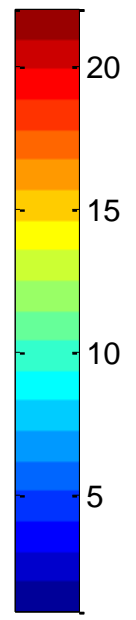
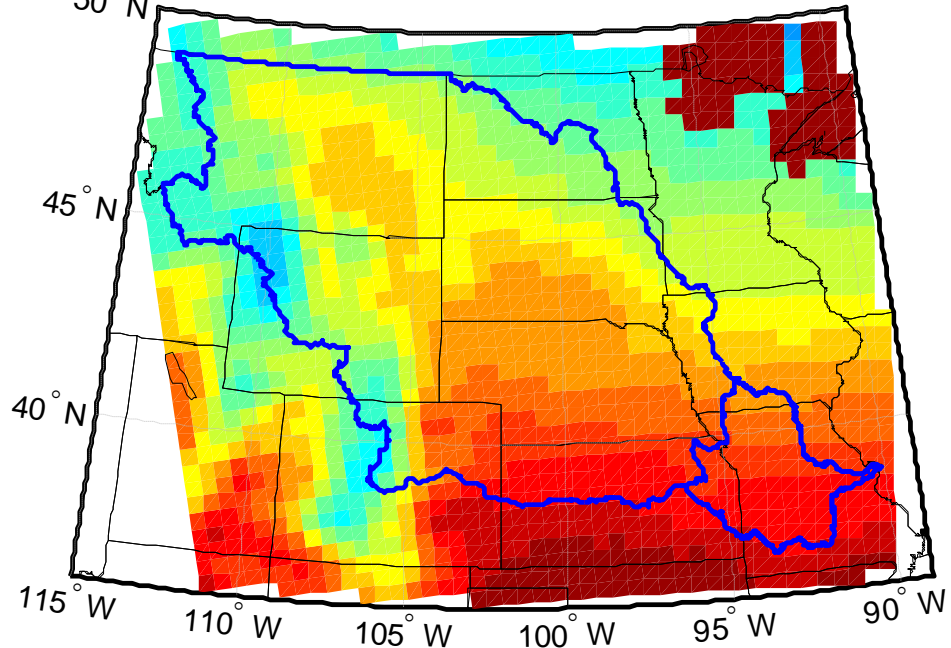
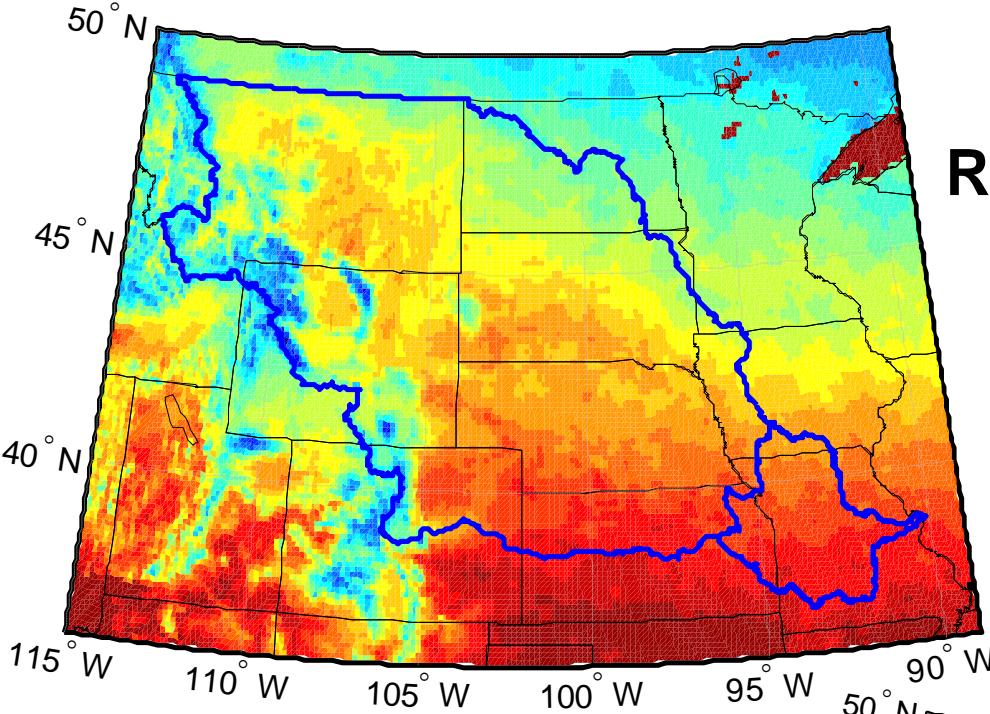


Resize observation dataset

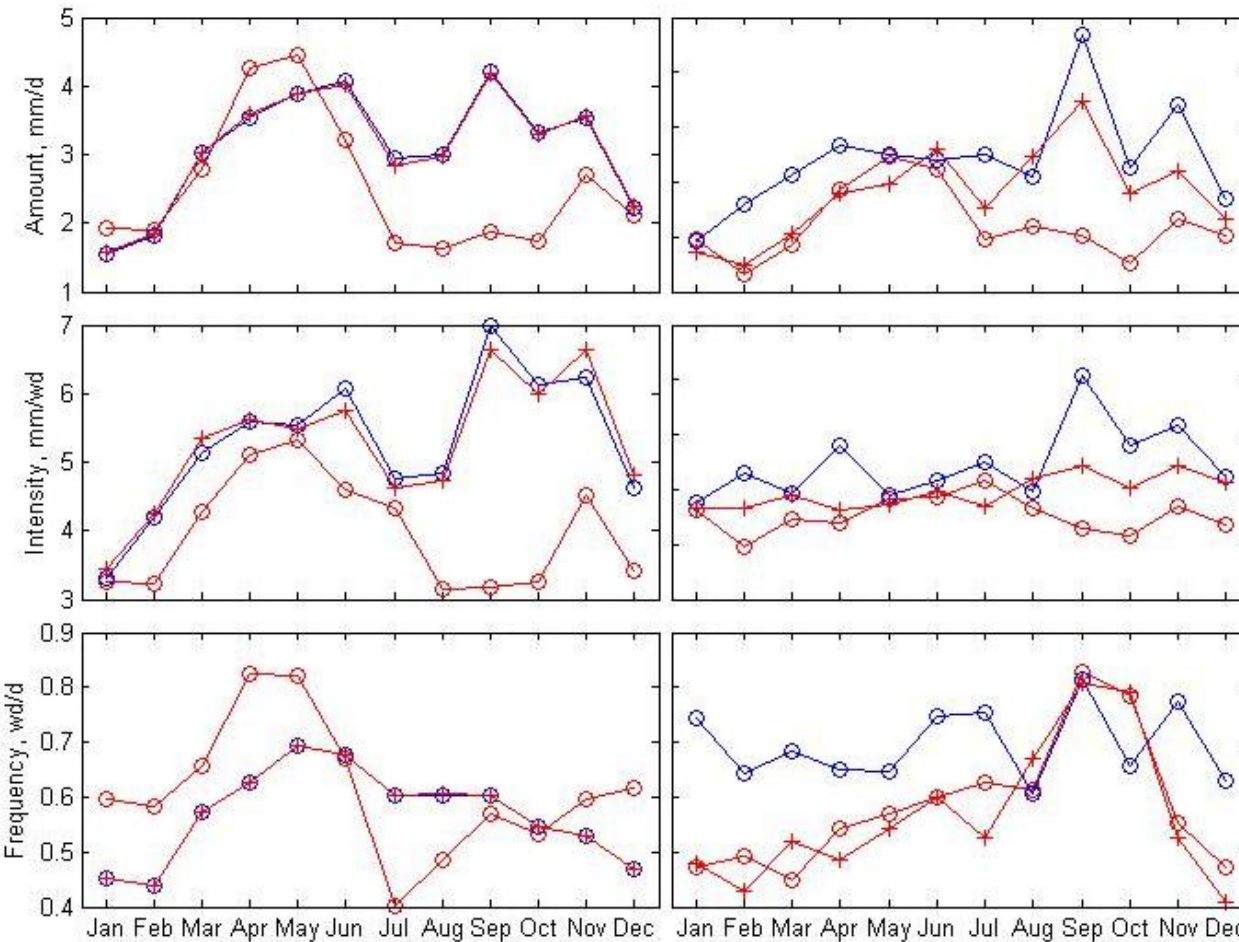
10km



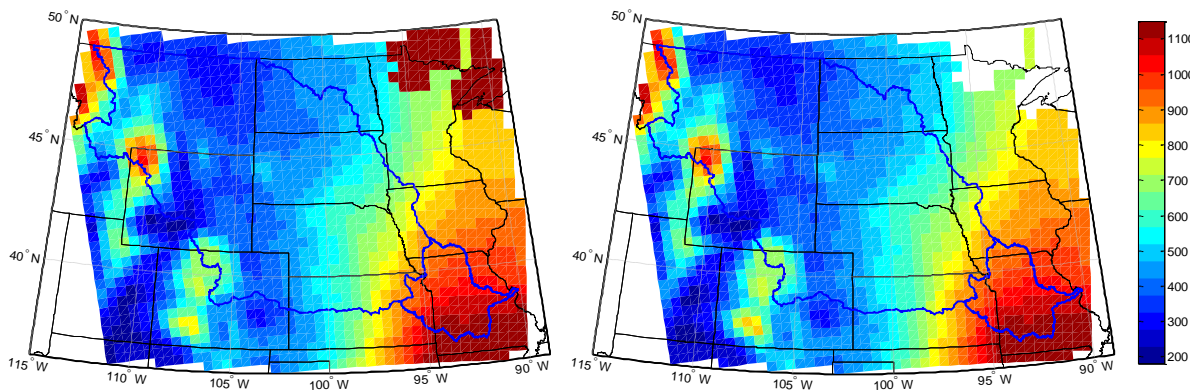
50km



Precipitation : after correction



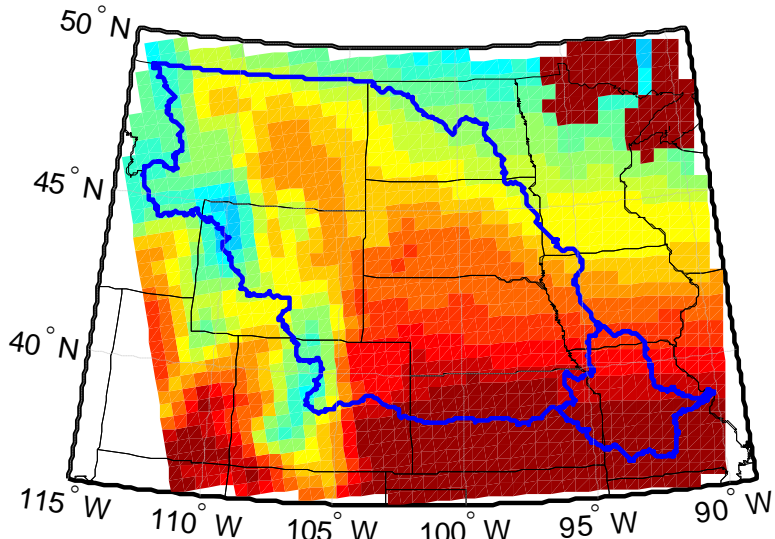
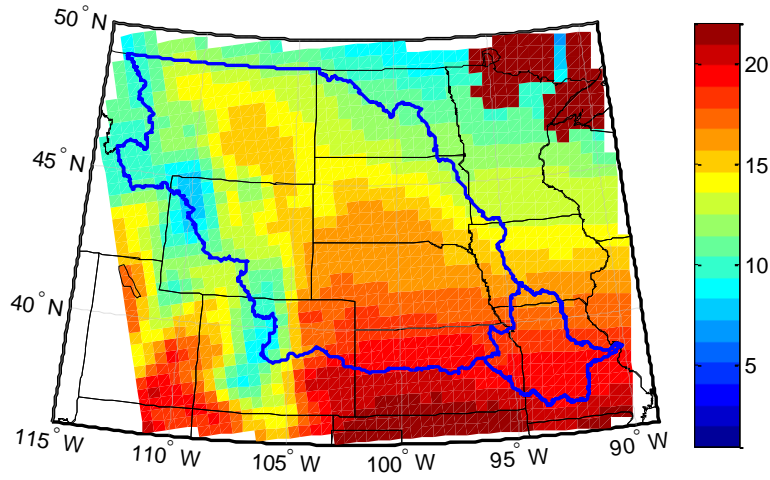
- Obs
- Crcm-cgcm3 (original)
- +— Crcm-cgcm3 (corrected)



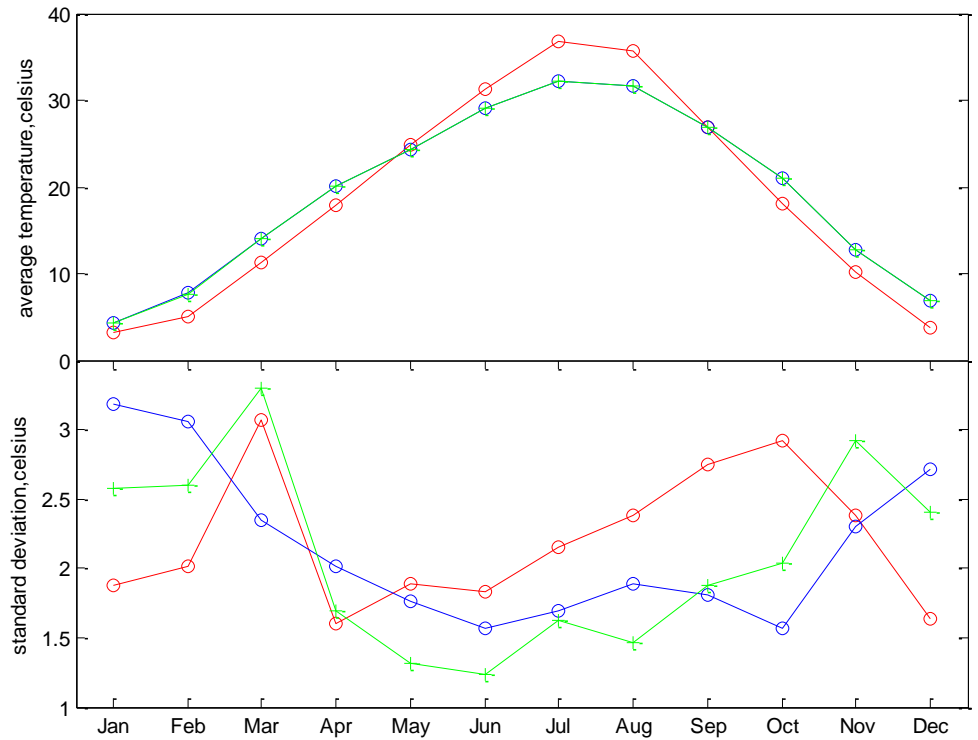
Left: UW data

Right: bias-corrected
crcm-cgcm3

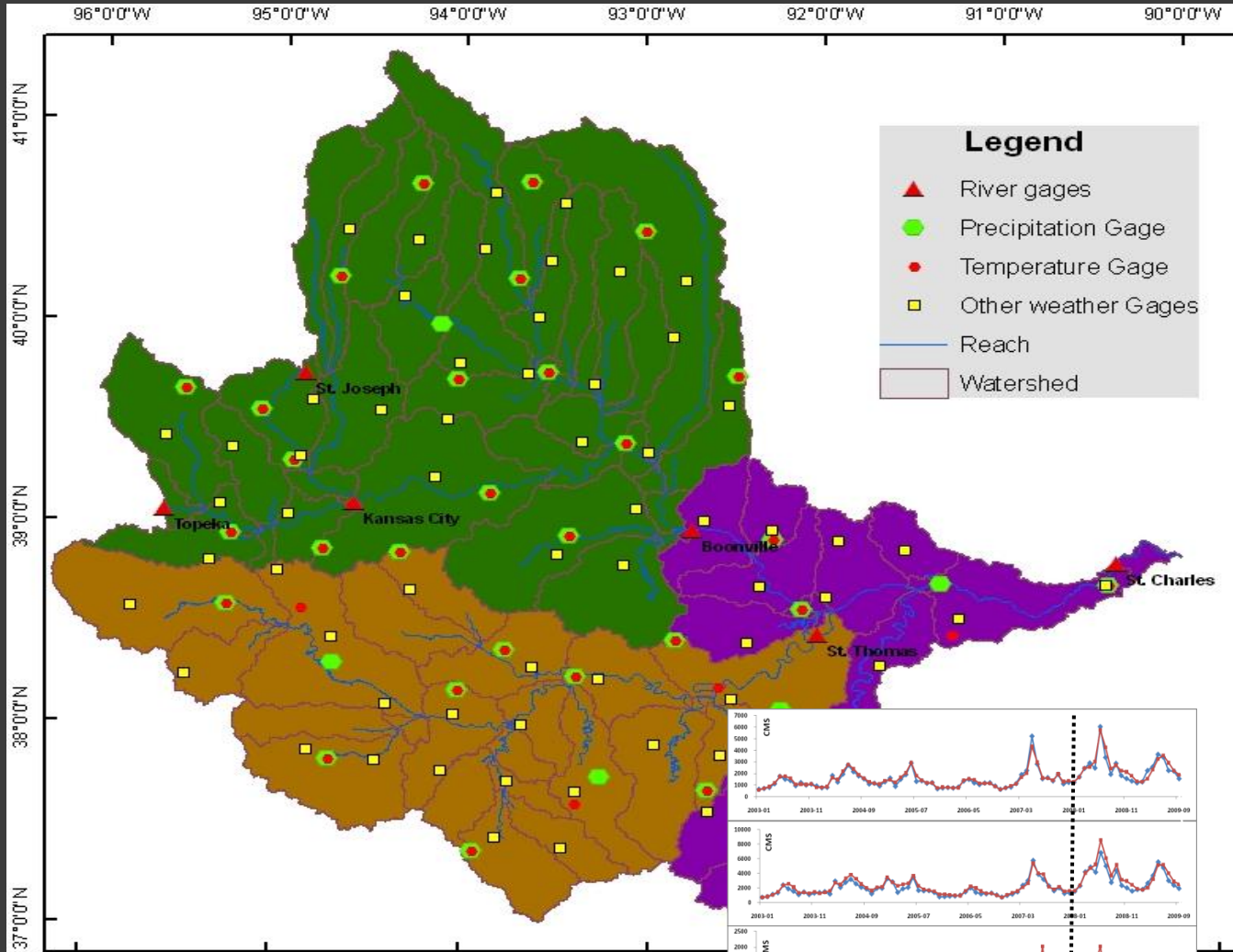
Temperature : after correction



top: UW data
bottom: bias-corrected
crcm-cgcm3



3. SWAT modeling of lower MoRB

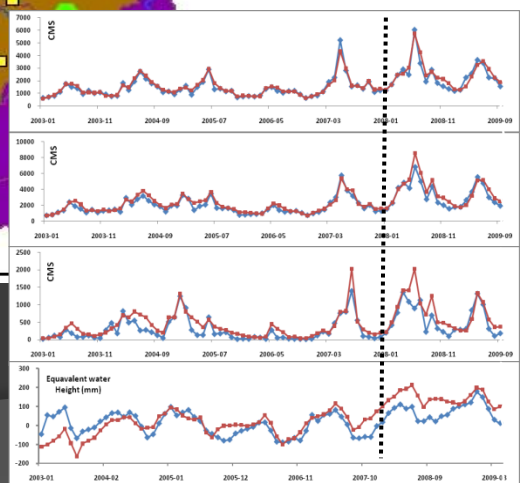
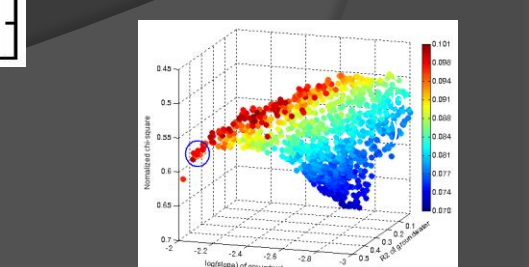
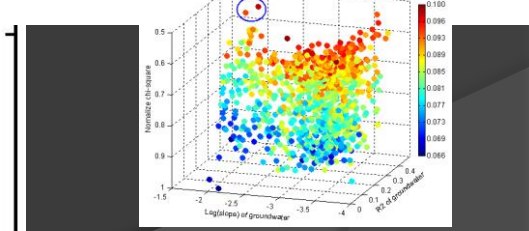
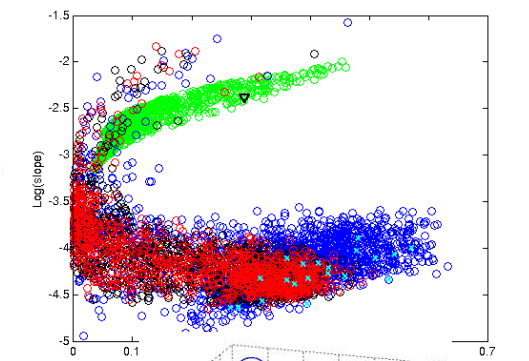


Legend

- ▲ River gages
- Precipitation Gage
- Temperature Gage
- Other weather Gages
- Reach
- ▭ Watershed

Name ^a	Definition	Default values	Priori distribution ^b	t-stat	p-value ^c
v__CH_N2.rte	Manning's N value for the main channels	0.014	0-0.3	77.39	0.00
v__ESCO.lrs	Soil evaporation compensation factor	0.95	0-1	24.54	0.00
u__CNC.mgl	SCS runoff curve number for moisture condition II	59-92	-30.5	-16.98	0.00
v__ALPHA_BF.gw	Baseflow alpha factor (days)	0.048	0-1	-5.61	0.00
v__SOL_AWC(1).sol	Available water capacity of first soil layer(mm/mm)	0.0-24	-0.5-0.5	-7.25	0.00
v__CANMX.kms	Canopy maximum storage (mm)	5.275	0-10	5.96	0.00
v__SMFMN.bsn	Melt factor for snow on 21 Dec.	4.5	0-10	-4.48	0.00
v__GW_REVAP.gw	Groundwater "revap" coefficient	0.02	0.02-0.2	2.77	0.01
v__SOL_BD(1).sol	Moist bulk density of first soil layer (Mg/m ³)	1.2-1.52	-0.3-0.3	2.38	0.02
v__SOL_K(1).sol	Saturated hydraulic conductivity of first soil layer (mm/hr)	0.48-600	-0.8-0.8	2.23	0.03
v__OV_N.lrs	Overland flow Manning's N value	0.01-0.3	0-2	2.22	0.03
v__SMFMX.bsn	Melt factor for snow on 21 Jun.	4.5	0-10	2.00	0.05
v__EPCO.lrs	Plant uptake compensation factor	1.0	0-1	-1.39	0.16
v__SURLAG.bsn	Surface runoff lag time (days)	4.0	10-10	-1.30	0.19
v__SFTMP.bsn	Snowfall temperature(°C)	1.0	-5-5	1.12	0.26
v__GW_DELAY.gw	Groundwater delay(days)	31	0-100	0.82	0.41
v__SMTMP.bsn	Snow melt temperature(°C)	0.5	-5-5	-0.42	0.68

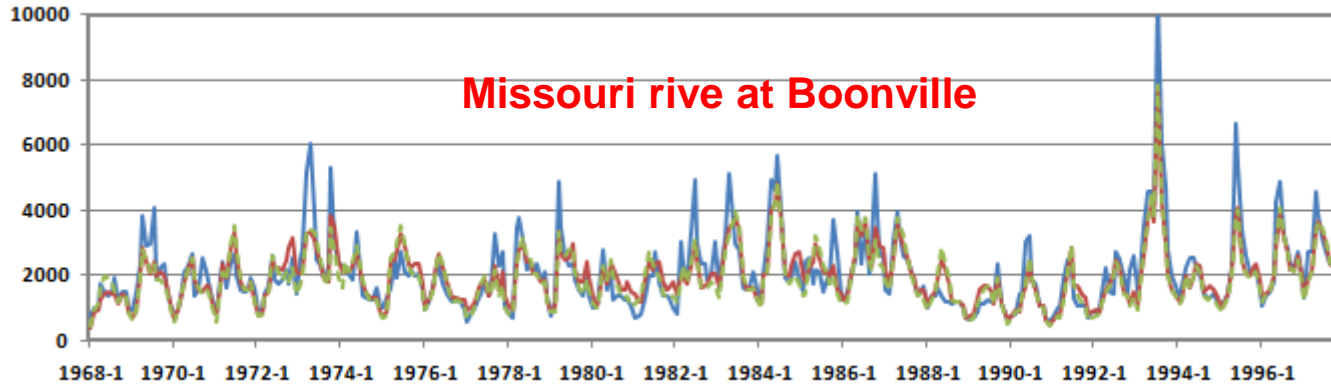
^a v__,"a," and "v__ means replacement, absolute change (initials-increments) and relative change (increments/initials)
^b Prior uniform distributions are based on Neitsch et al. 2001, Yang et al. 2007 and 2008, and Migliaccio and Chaubey, 2008.
^c P < 0.05 is considered statistically significant.



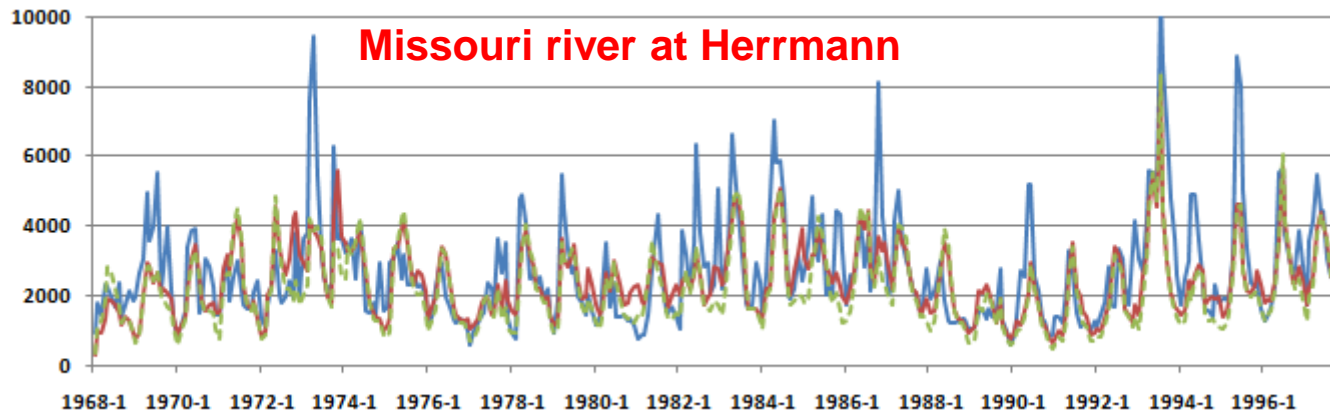
(Soil and Water Assessment Tool)

4. Streamflow output with NARCCAP inputs

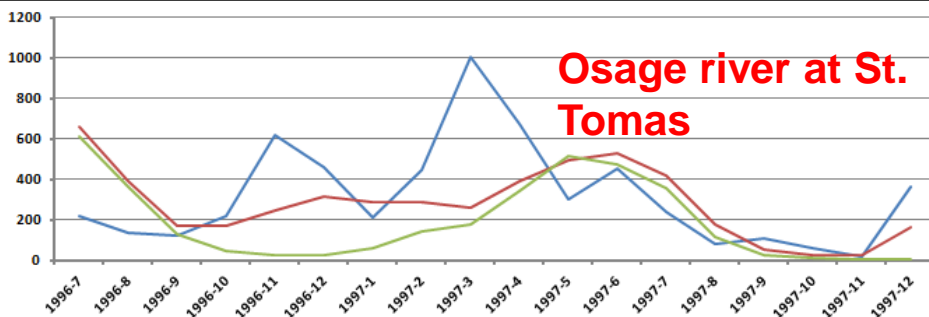
CMS


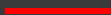



CMS

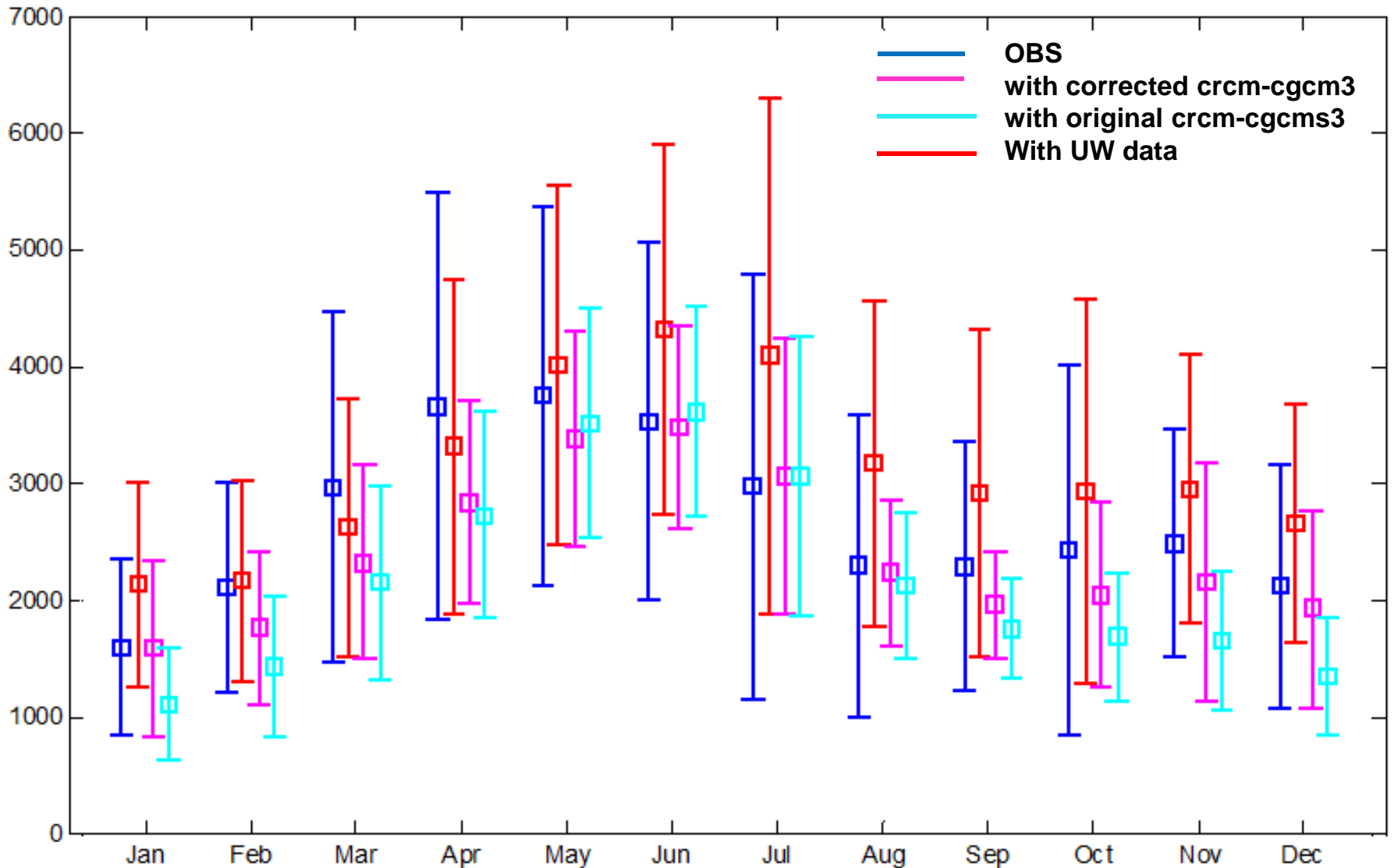


CMS



-  OBS
-  with corrected crcm-cgcms
-  with original crcm-cgcms3

Means and standard deviations at Herrmann discharge



5. Preliminary conclusion

- The bias–corrected CRCM-CGCM3 can be used to improve the watershed hydrology simulations.
- However, it still tends to under-estimate the streamflow, especially for the peak flows.

Acknowledgements

- **Thanks NCAR for supporting me this travel**
- **We wish to thank the North American Regional Climate Change Assessment Program (NARCCAP) for providing the data used in this paper. NARCCAP is funded by the National Science Foundation (NSF), the U.S. Department of Energy (DoE), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Environmental Protection Agency Office of Research and Development (EPA).**
- **NCEP Reanalysis data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at <http://www.esrl.noaa.gov/psd>. GRACE land data were processed by Sean Swenson, supported by the NASA MEASURES Program, and are available at <http://grace.jpl.nasa.gov>**
- **CPC US Unified Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at <http://www.esrl.noaa.gov/psd/> in any documents or publications using these data.**
- **Daily gridded meteorological data obtained from the Surface Water Modeling group at the University of Washington from their web site at <http://www.hydro.washington.edu/Lettenmaier/Data/gridded/>, the development of which is described by Maurer et al. (2002):**