

Climate Model Biases and Statistical Downscaling for Application in Hydrologic Model

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Department of Biological Engineering**

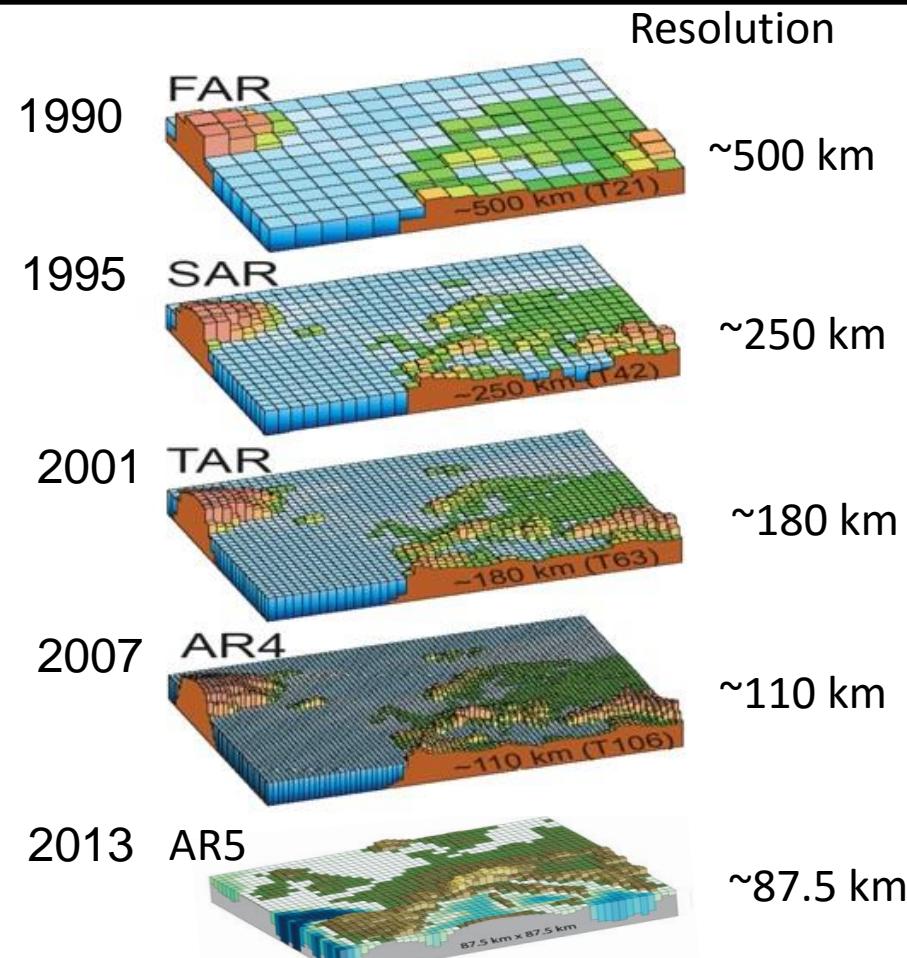
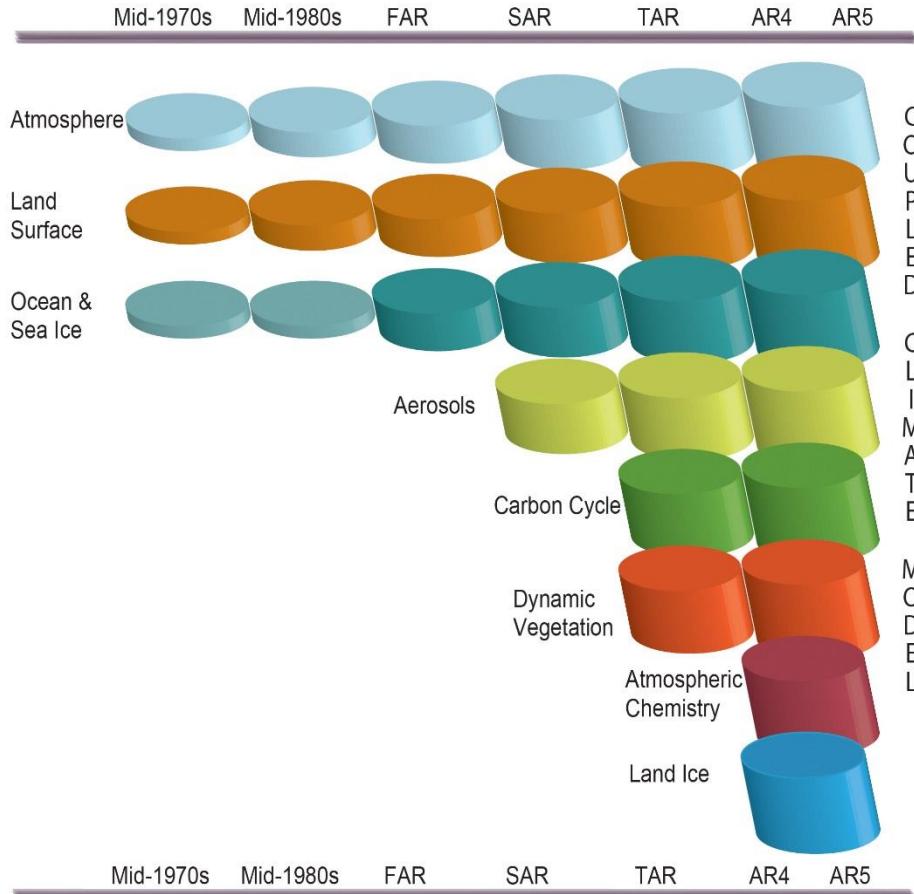
Outline

- Climate change and hydrology
- Global Circulation Model (GCM)
- Coupled Model Inter-comparison Project Phase 5 (CMIP5)
 - Representative Concentration Pathways (RCPS)
- Climate model bias
- Statistical downscaling of precipitation and temperature for hydrological modeling
 - Delta Method
 - Quantile mapping
- Results
- Conclusions

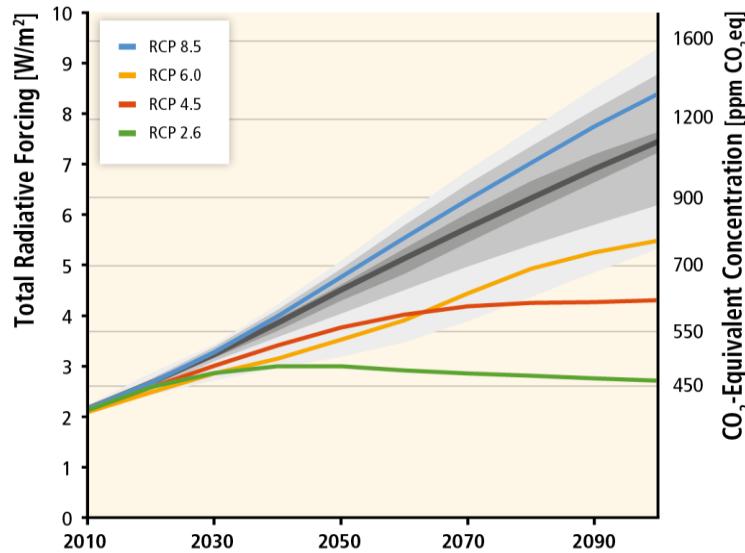
Introduction

- Climate change is expected to have significant impacts on global temperature and precipitation change
- Output from the climate model are used to predict the climate change impact on hydrology
 - Coupling climate and hydro-model
- Scale of operation of climate model and the hydro-model are different
 - Need some sort of correction
 - Downscaling

Global Circulation Model(GCM)

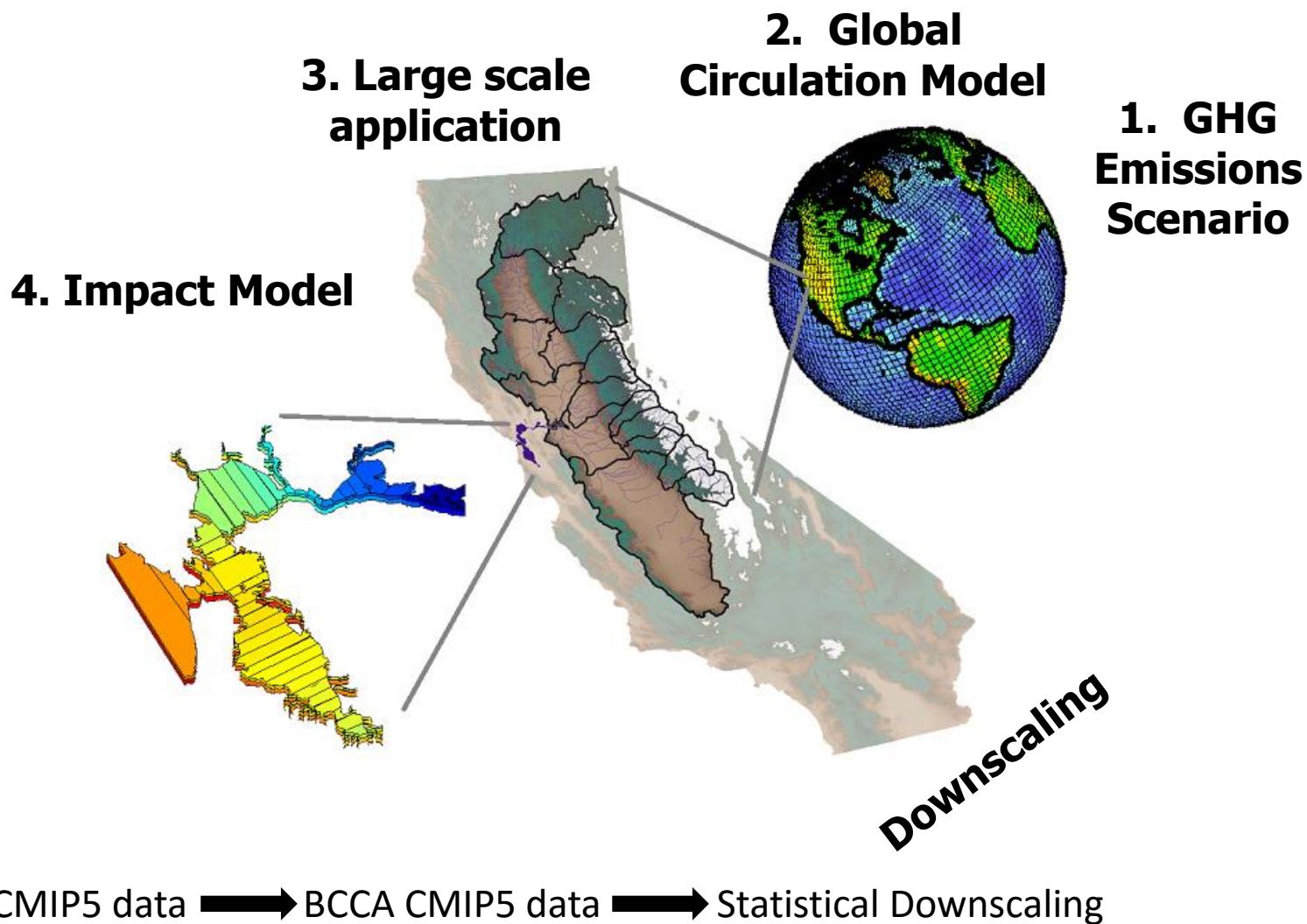


Representative Concentration pathways(RCM)



Name	Radiative forcing	Concentration (ppm)	Temp anomaly (°C)	SRES temp anomaly equiv
RCP8.5	>8.5 W m ⁻² in 2100	>1,370 CO ₂ -equiv.	4.9	SRES A1F1
RCP4.5	~4.5 W m ⁻² at stabilization after 2100	~650 CO ₂ -equiv.	2.4	SRES B1

Estimating Climate Change Impact on Hydrology

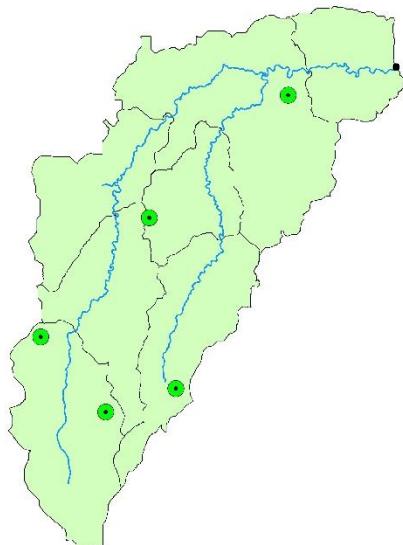


Adapted from Cayan and Knowles, SCRIPPS/USGS, 2003

Study Area



**Location of
Goodwater creek
Experimental
watershed in the
state of MO**

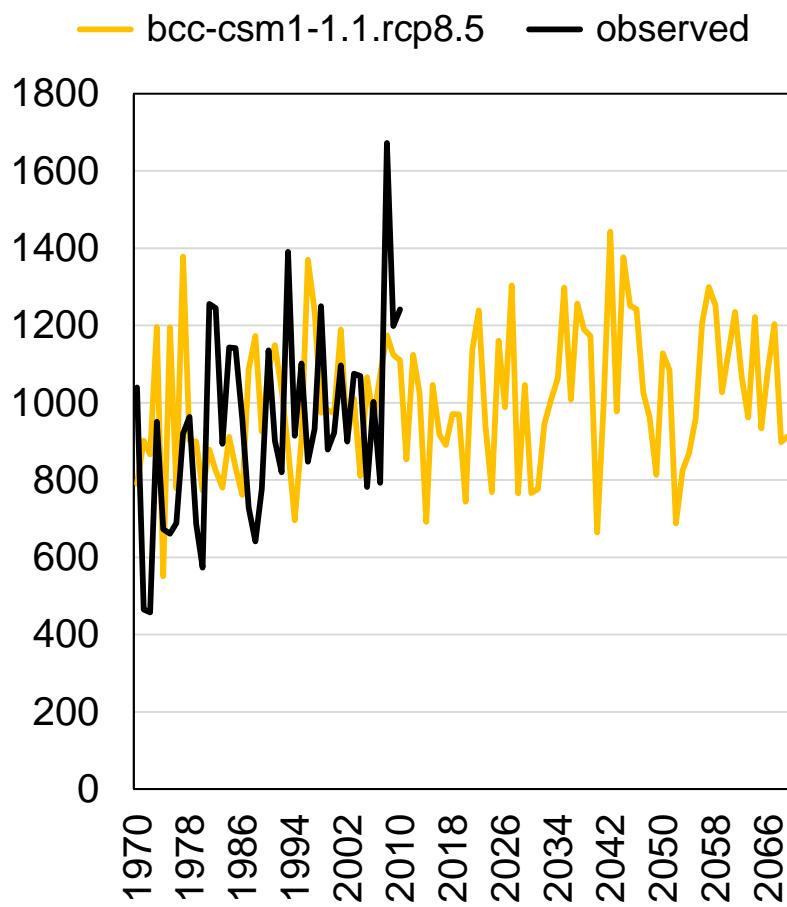
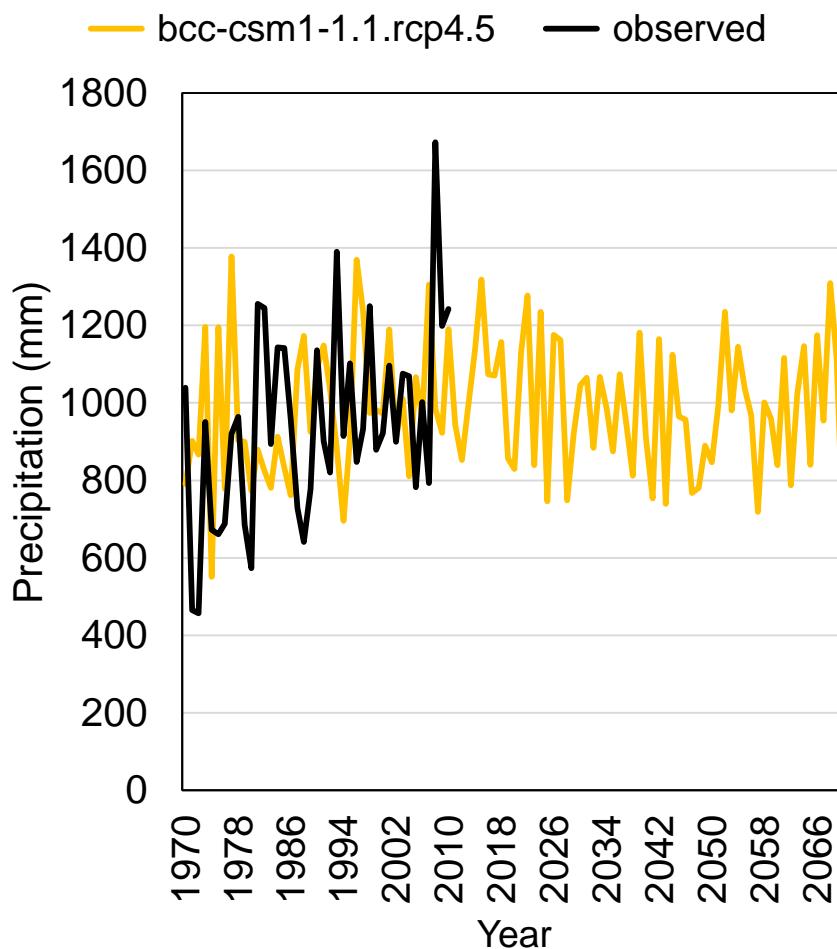


Legend

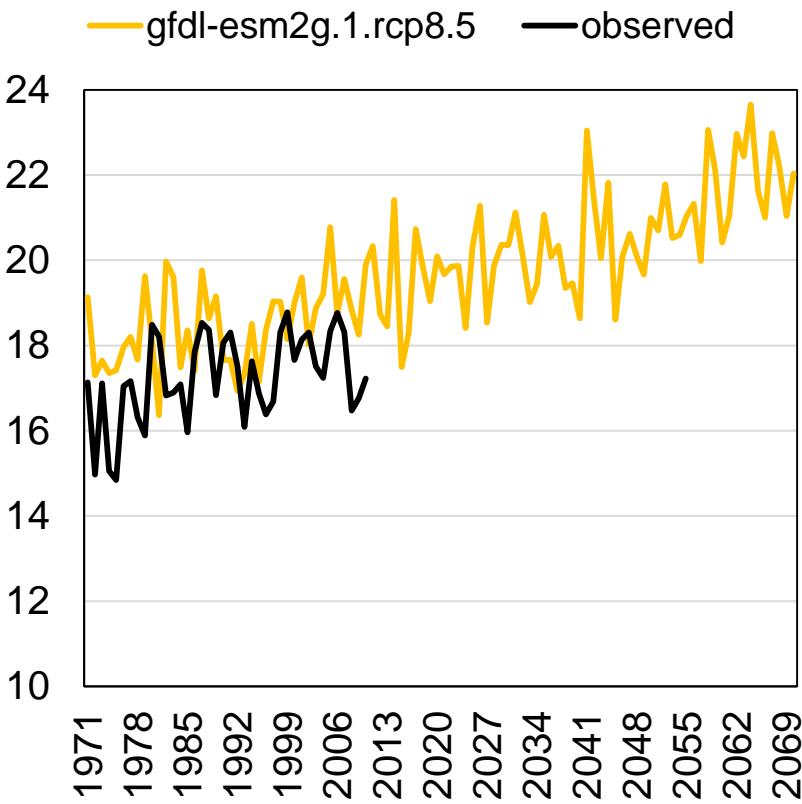
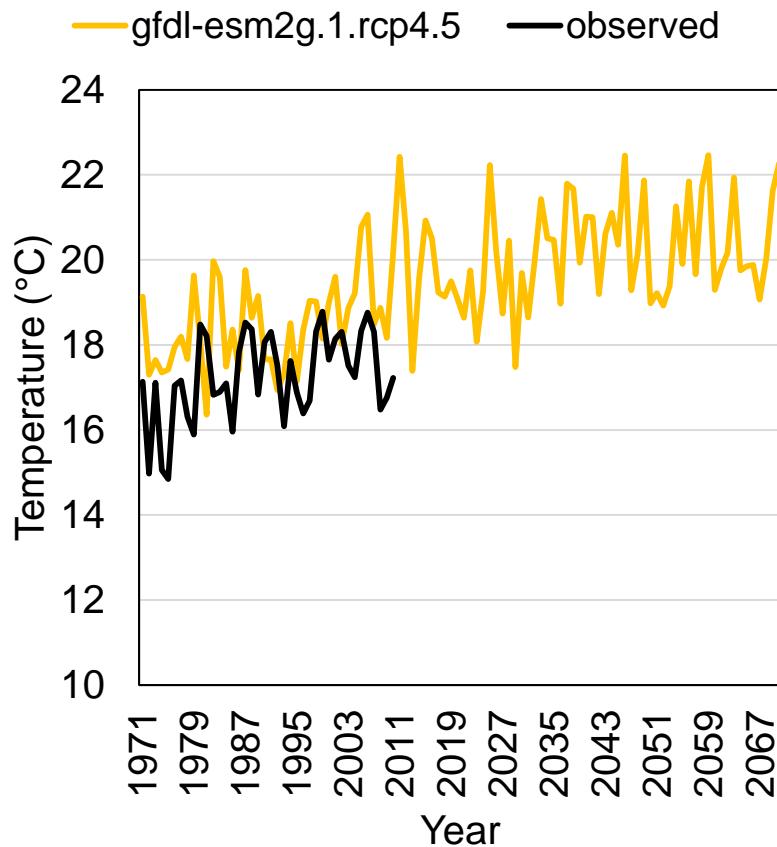
- Weather station
- reach
- Goodcreek

- Drainage Area: 73.4 Km²
- Experimental watershed with long-term hydrologic dataset and well-calibrated SWAT model
- Daily Bias Correction Constructed Analogs (BCCA) downscaled datasets (1/8 degree) were downloaded from <http://gdo-dcp.ucllnl.org/>
- Downscaled data showed bias when compared to observed data
- This bias can influence impact assessment

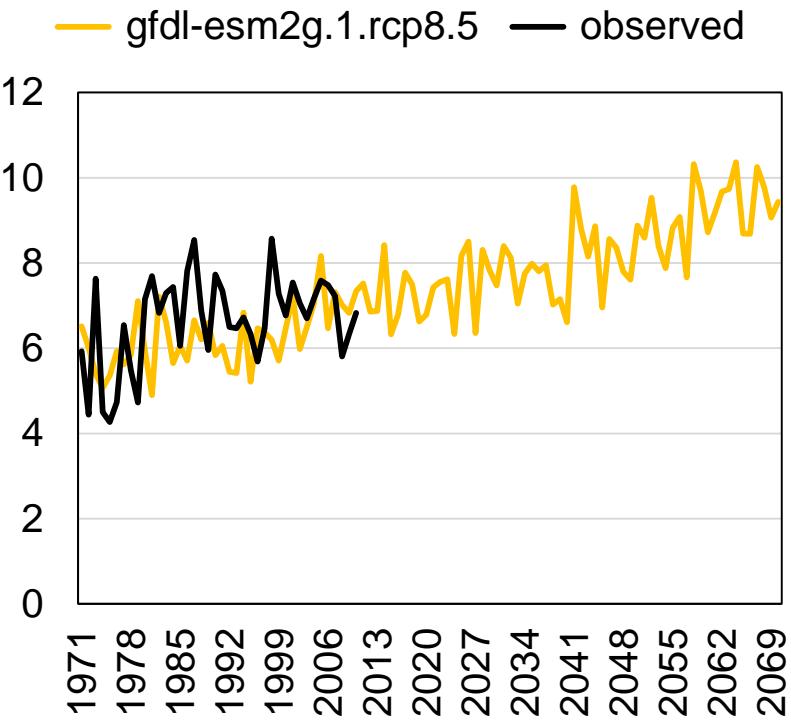
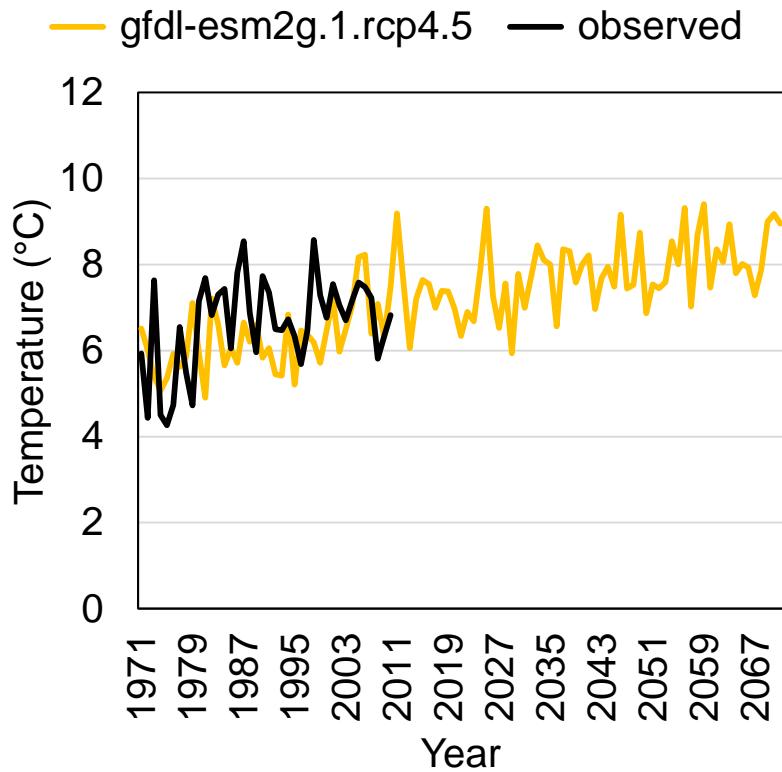
Precipitation – Historical and CMIP5



Yearly Max. Temperature – Historical and CMIP5



Yearly Min. Temperature – Historical and CMIP5



Downscaling

Simple Downscaling

- Applying coarse scale climate changes to the observed data

Dynamic Downscaling

- Involves using numerical meteorological modeling to reflect how global patterns affect local weather conditions
- Able to simulate local conditions in greater detail
- Still has some bias
- Need more computational power

Statistical Downscaling

- Based on stationary transfer function
eg. Delta method, Quantile mapping

Statistical Downscaling

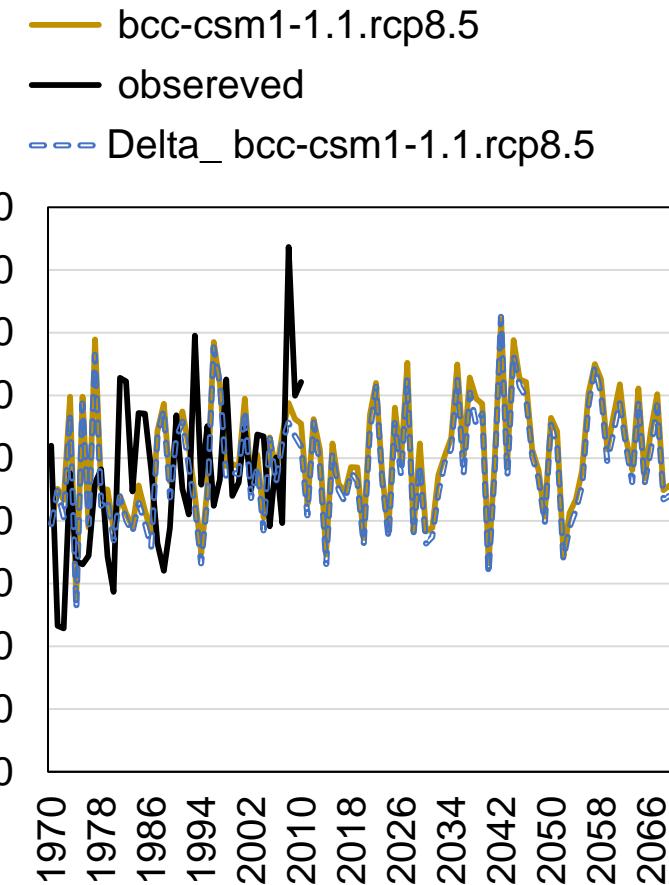
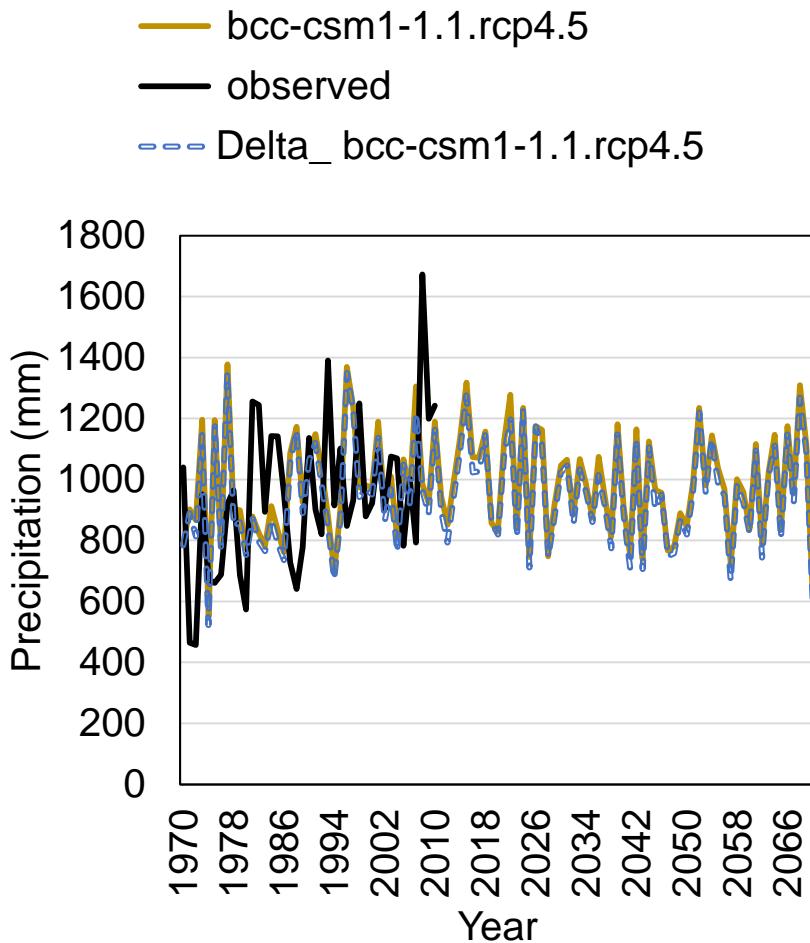
Delta method:

- Linearly shifting every model data by scaling factor
- Monthly scale factor is calculated

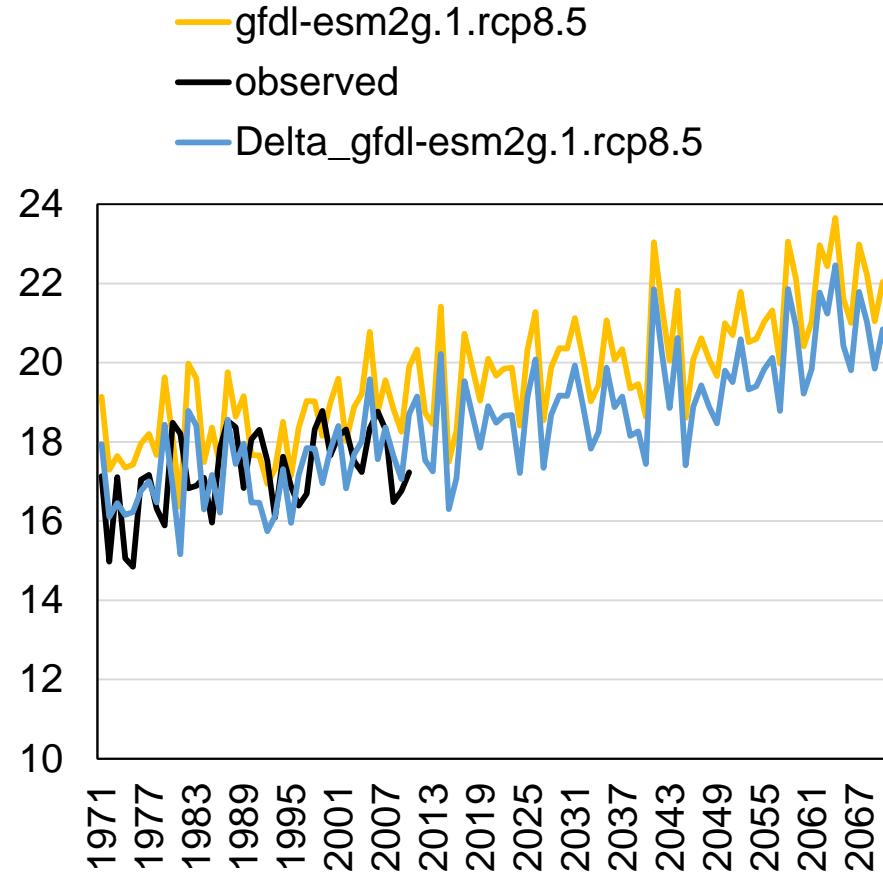
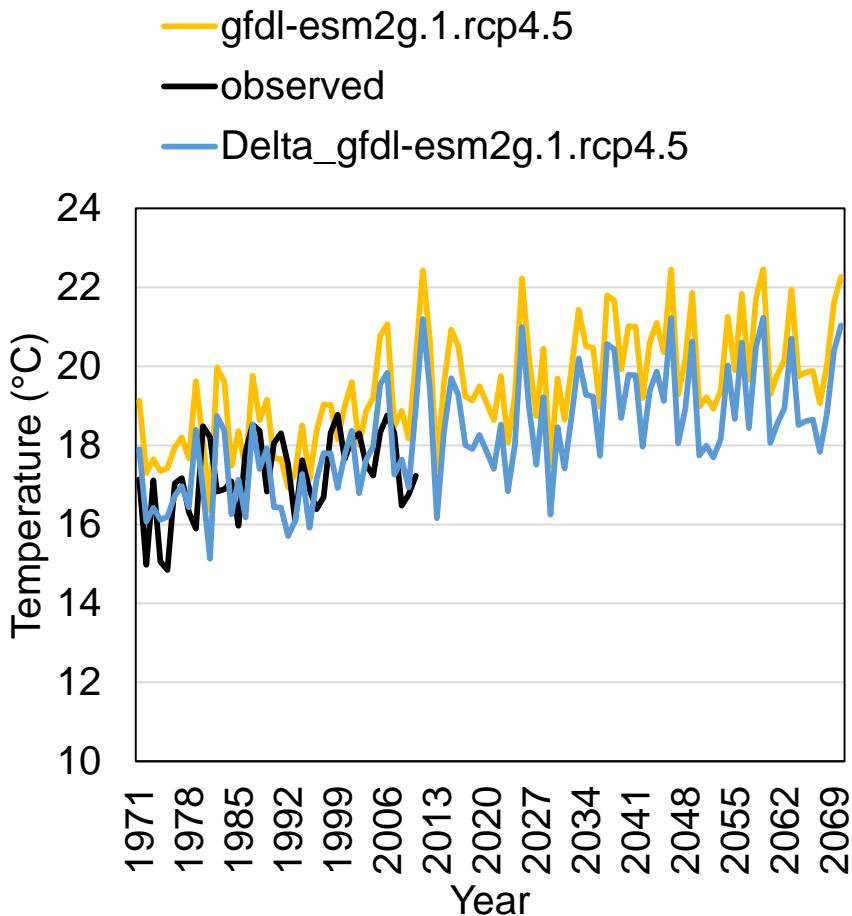
Quantile Mapping:

- Calculate the quantiles (median, quartiles, etc.) for observed data and GCM historical data
- Apply linear transformation to each quantile of GCM data to adjust its range to match the quantile in observed data
- Apply same correction to the quantiles of the future data

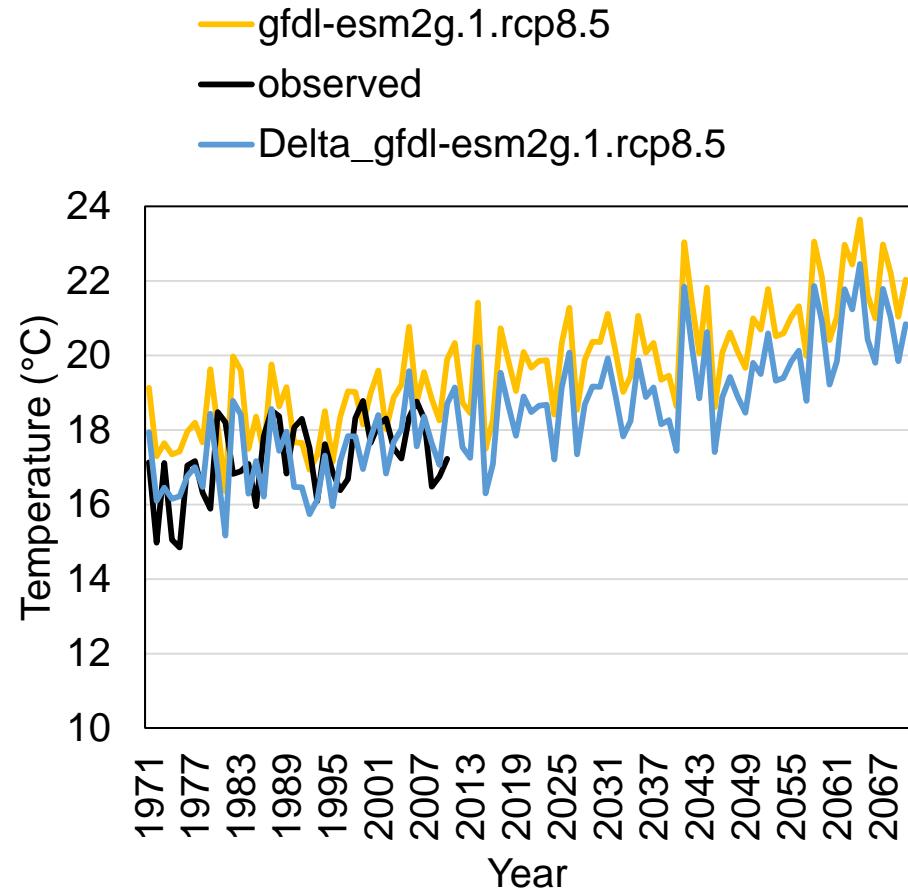
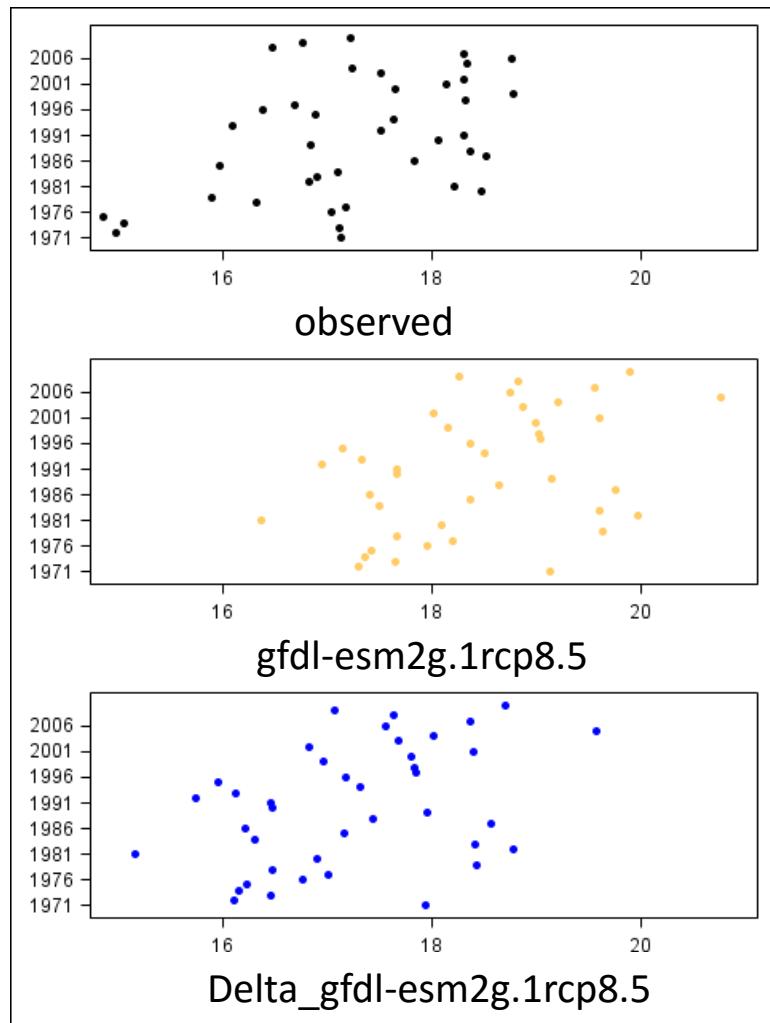
Delta Method-Precipitation



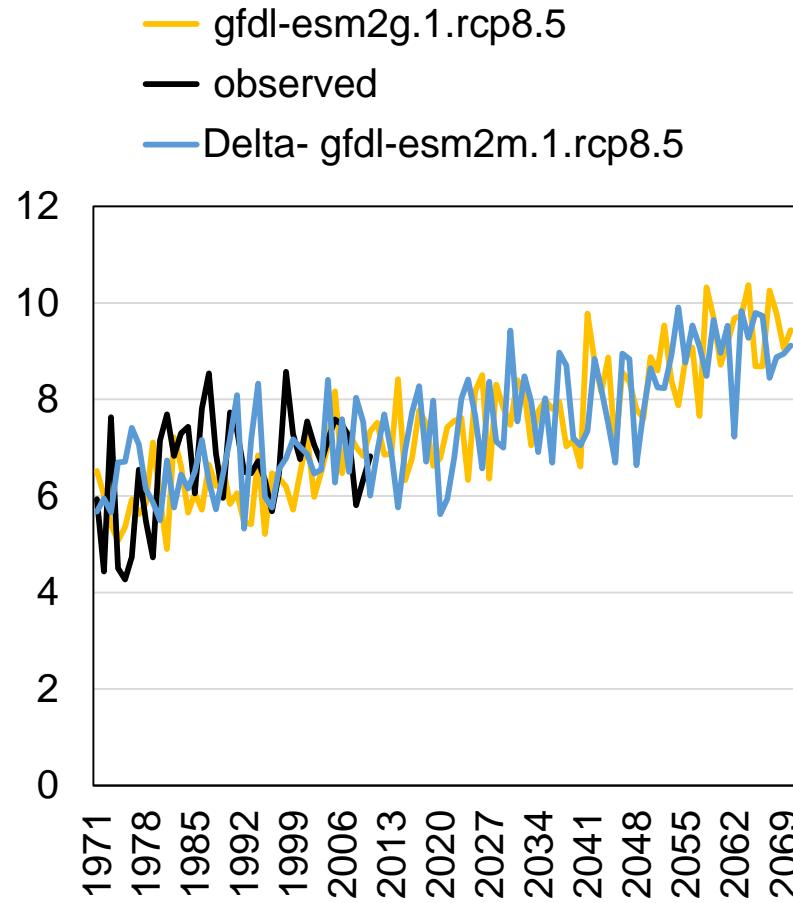
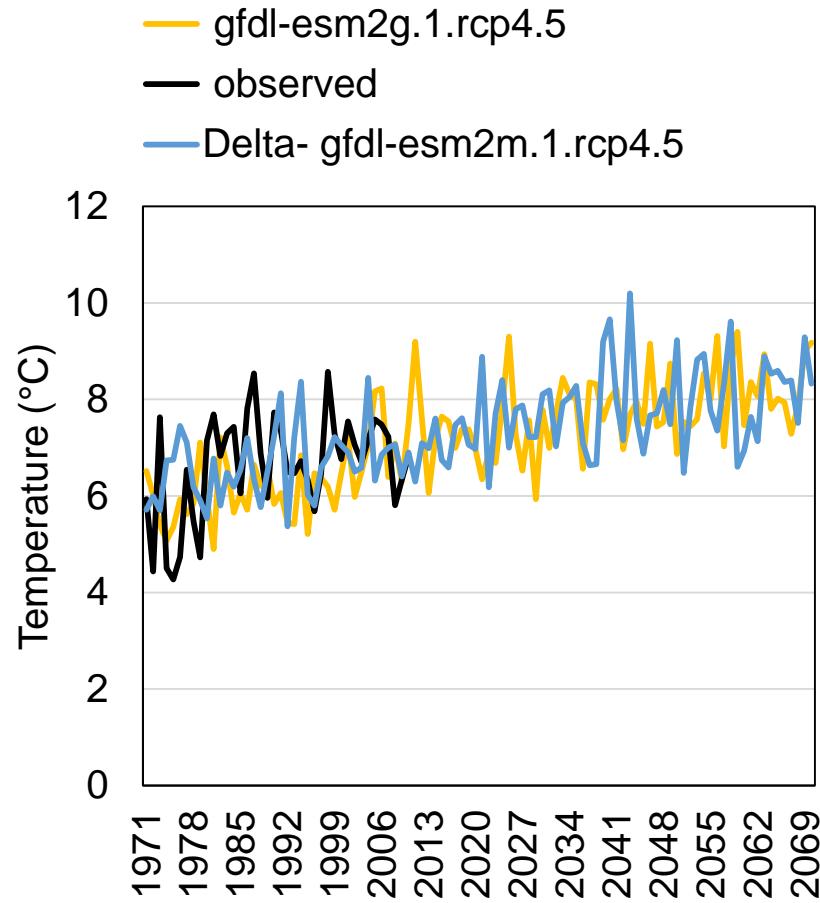
Delta Method-Max. Temperature



Delta Method-Max. Temperature

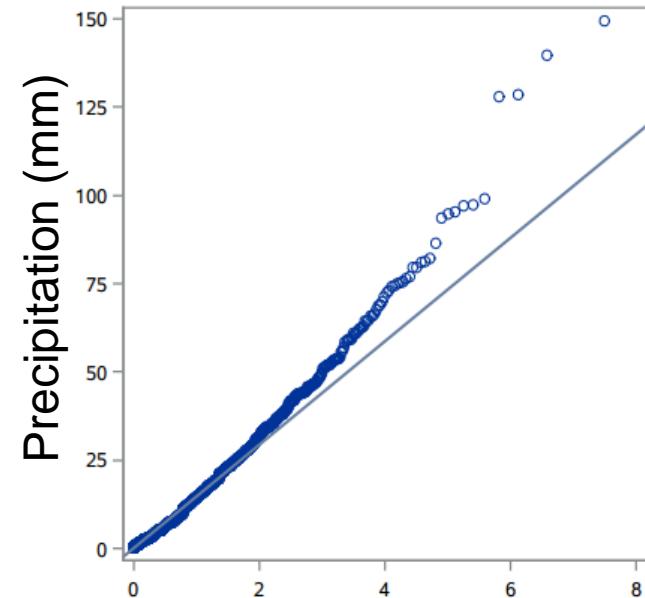


Delta Method-Min. Temperature



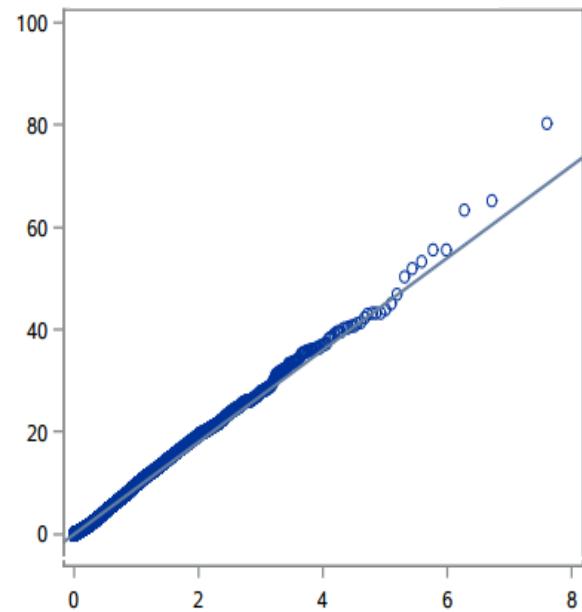
Quantile Mapping

observed



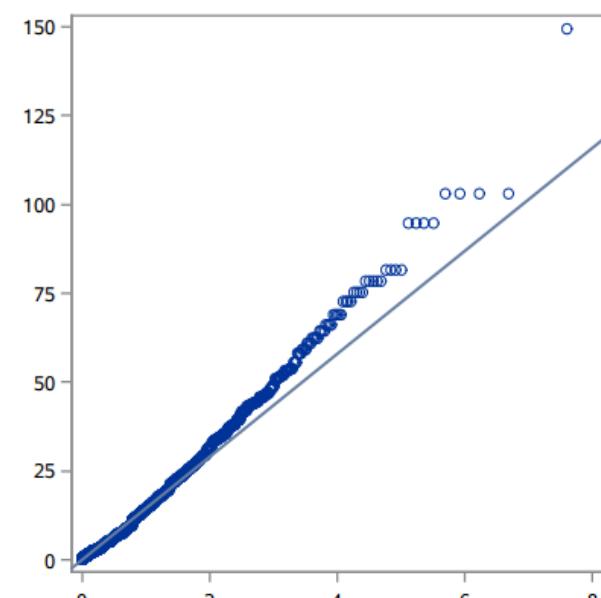
Gamma Quantiles
Alpha=0.602
Scale=14.611

uncorrected CMIP5



Gamma Quantiles
Alpha=0.356
Scale=8.726

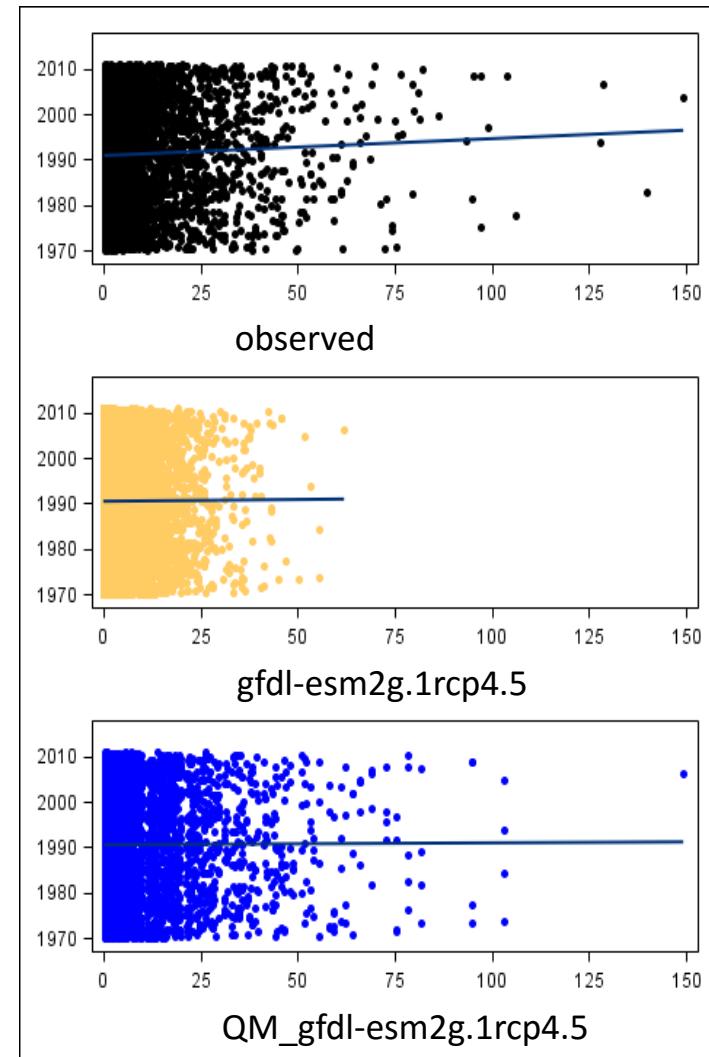
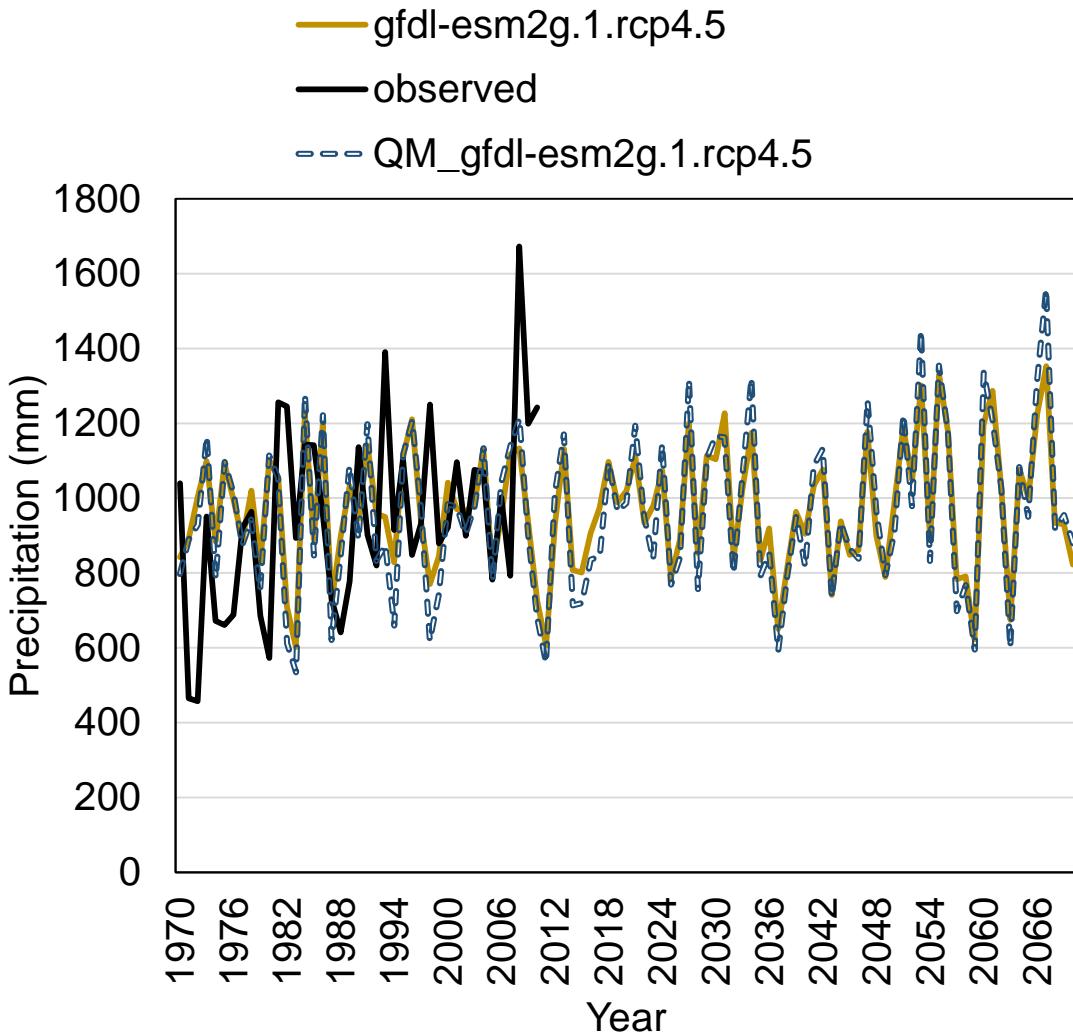
corrected CMIP5



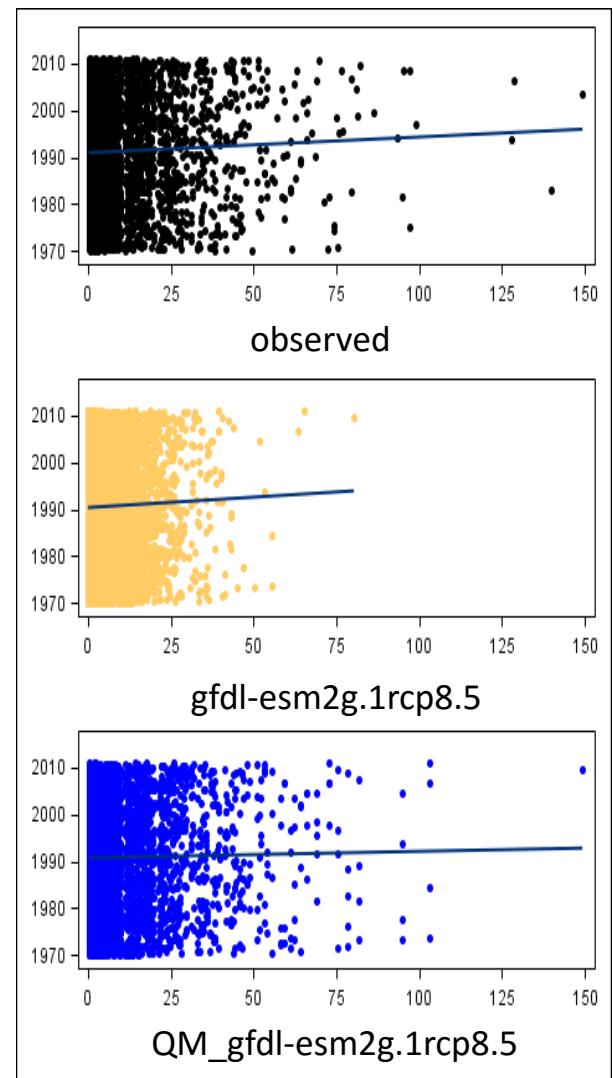
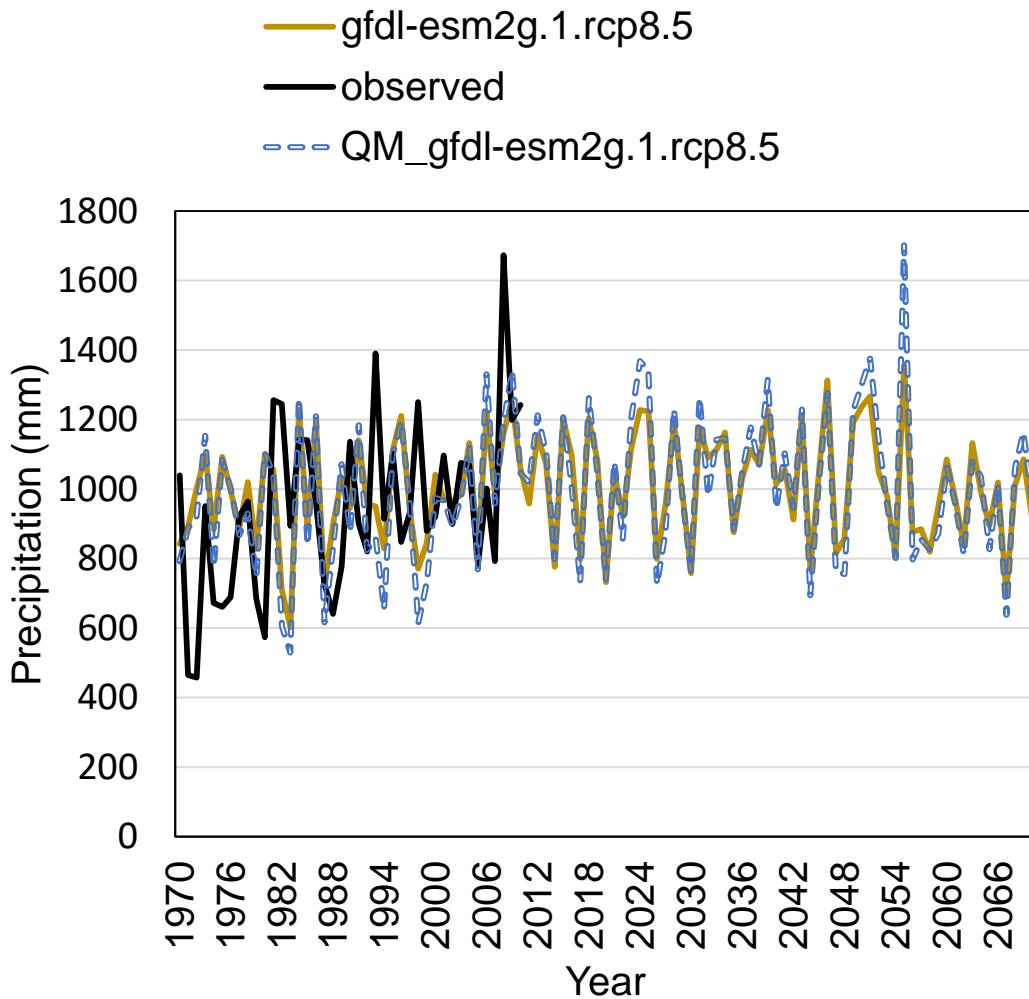
Gamma Quantiles
Alpha=0.603
Scale=14.457

Distribution of the precipitation data follows the gamma distribution.

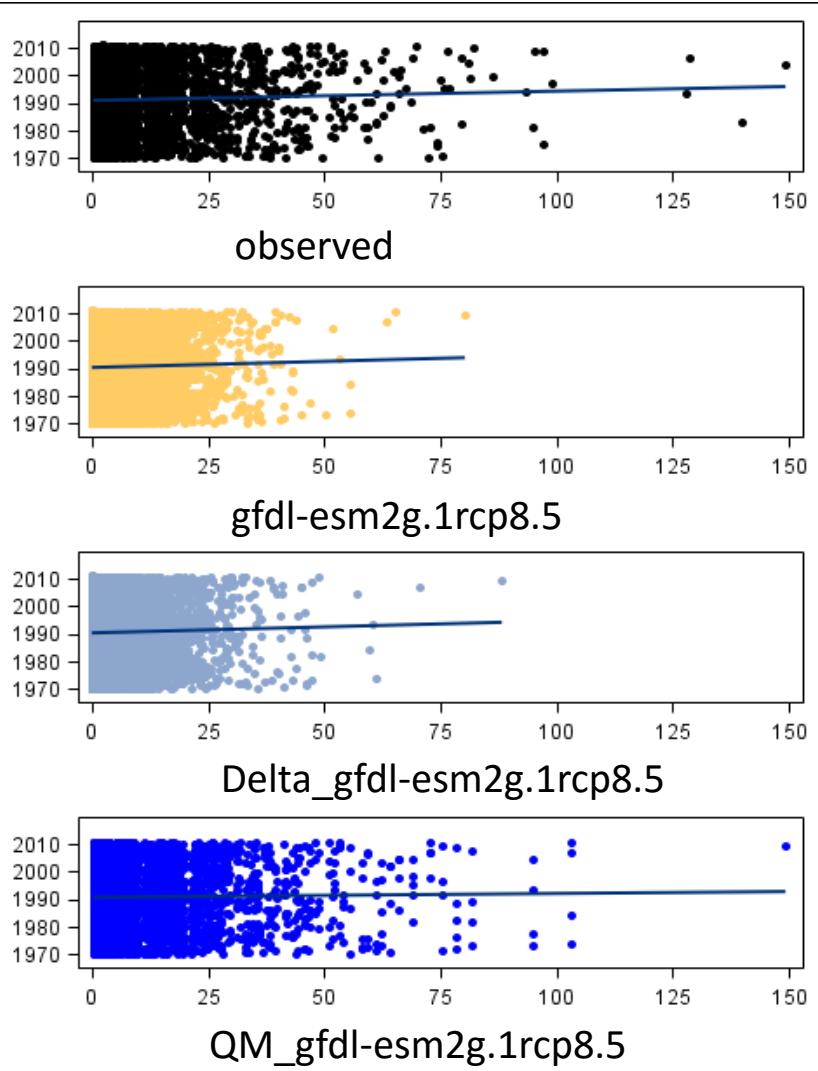
Results-Quantile Mapping



Results-Quantile Mapping



Results



- Comparison of the daily precipitation amount shows that quantile mapping work better than delta method

Conclusions

- Even the best available downscaled BCCA CMIP5 data has bias for its application for impact assessment in smaller scale
- Delta method was able to correct the bias for daily temperature data
- Quantile mapping turn out to be a better bias correction method for daily precipitation data
 - Daily max, yearly max and min value were well represented

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