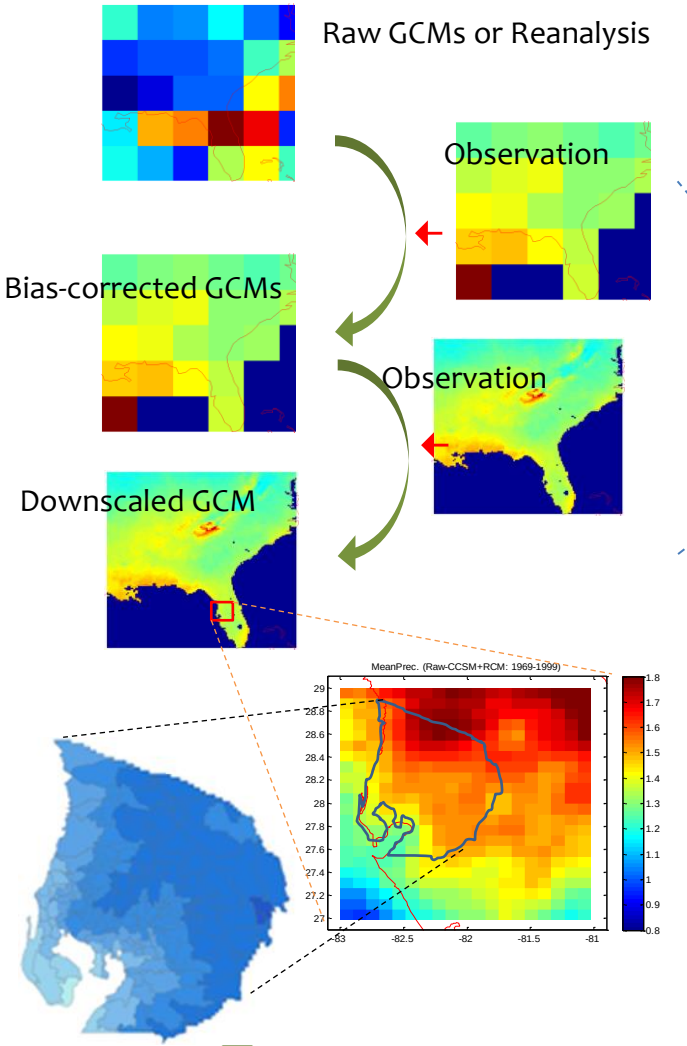
Climate Change Impact Assessment
over West Central Florida
using ***CLAREnCE10*** data from FSU

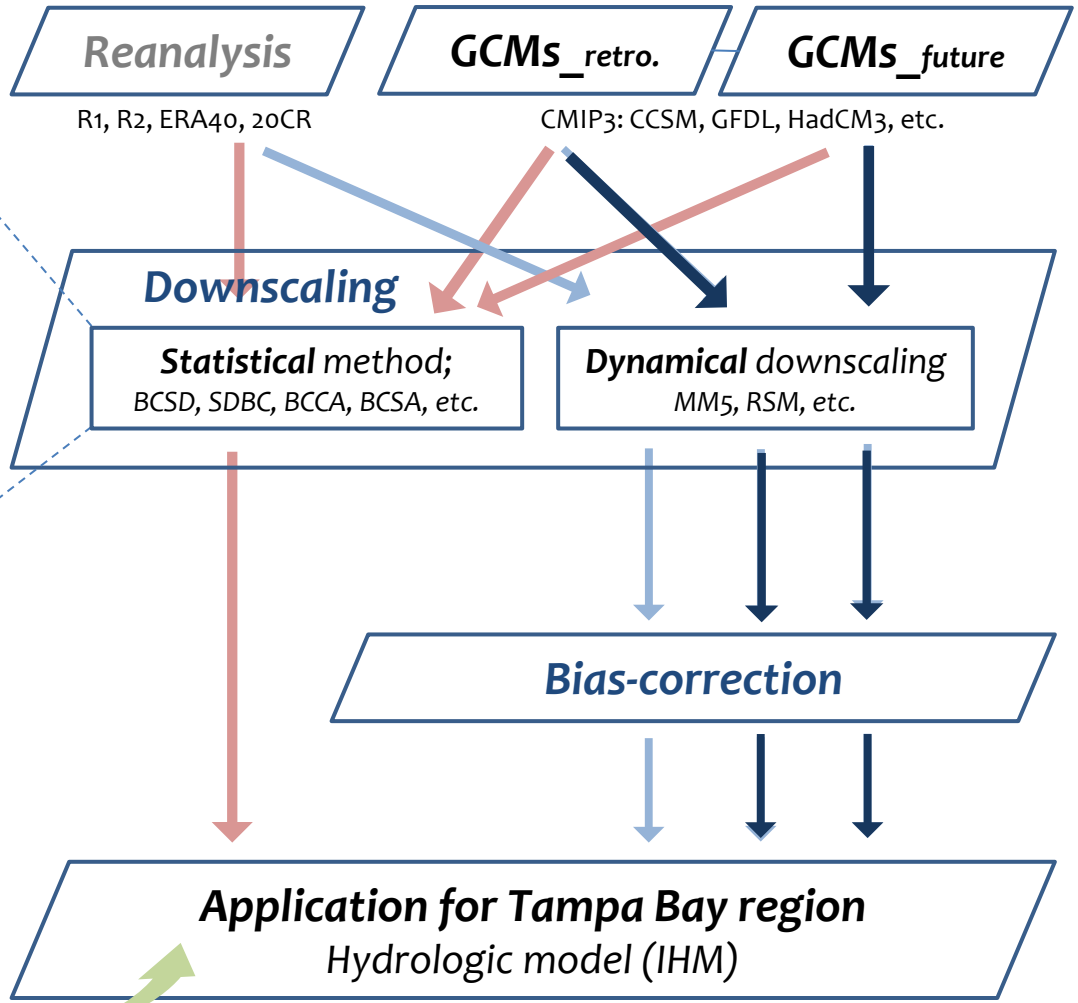
Results based on 3 ***GCMs*** *and 3* ***CDF construction tech. for bias-correction***

Feb. 27. 2013

Syewoon Hwang, Wendy Graham

Water Institute Research





Florida Water & Climate Alliance

UF Water Institute University of Florida

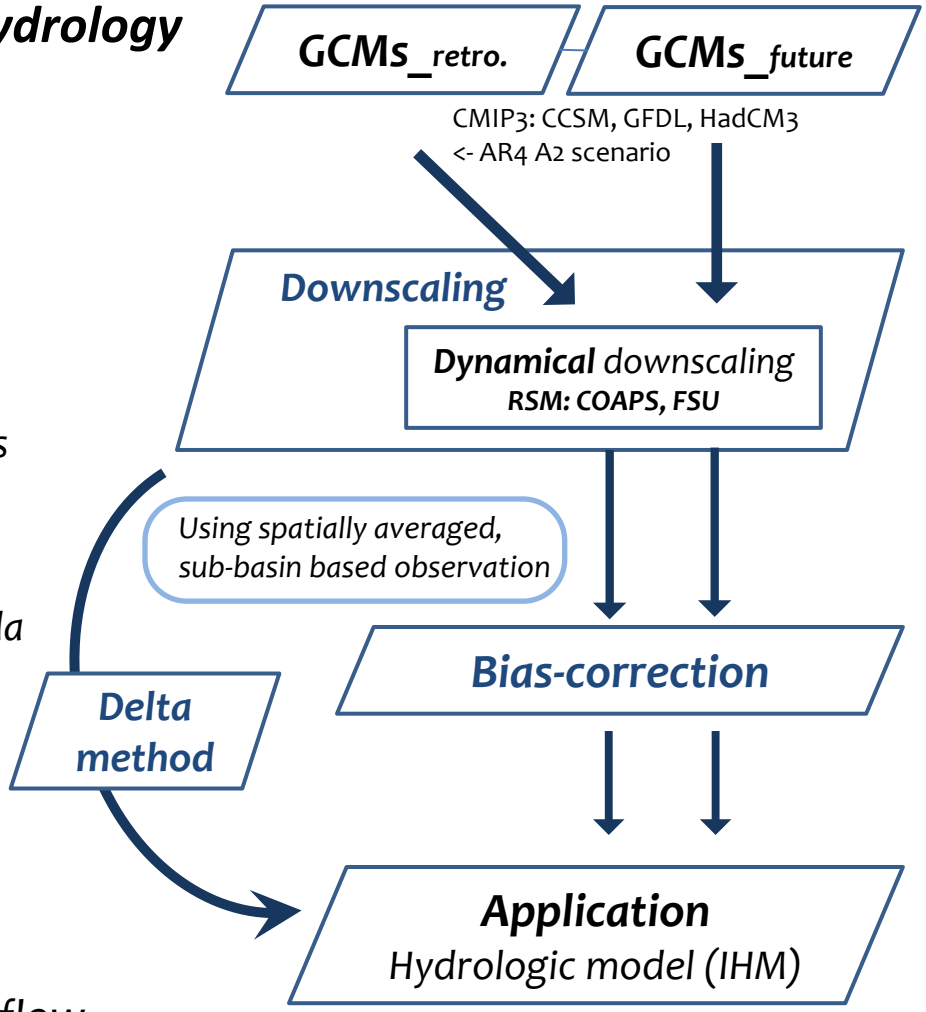
NOAA

Tampa Bay Water

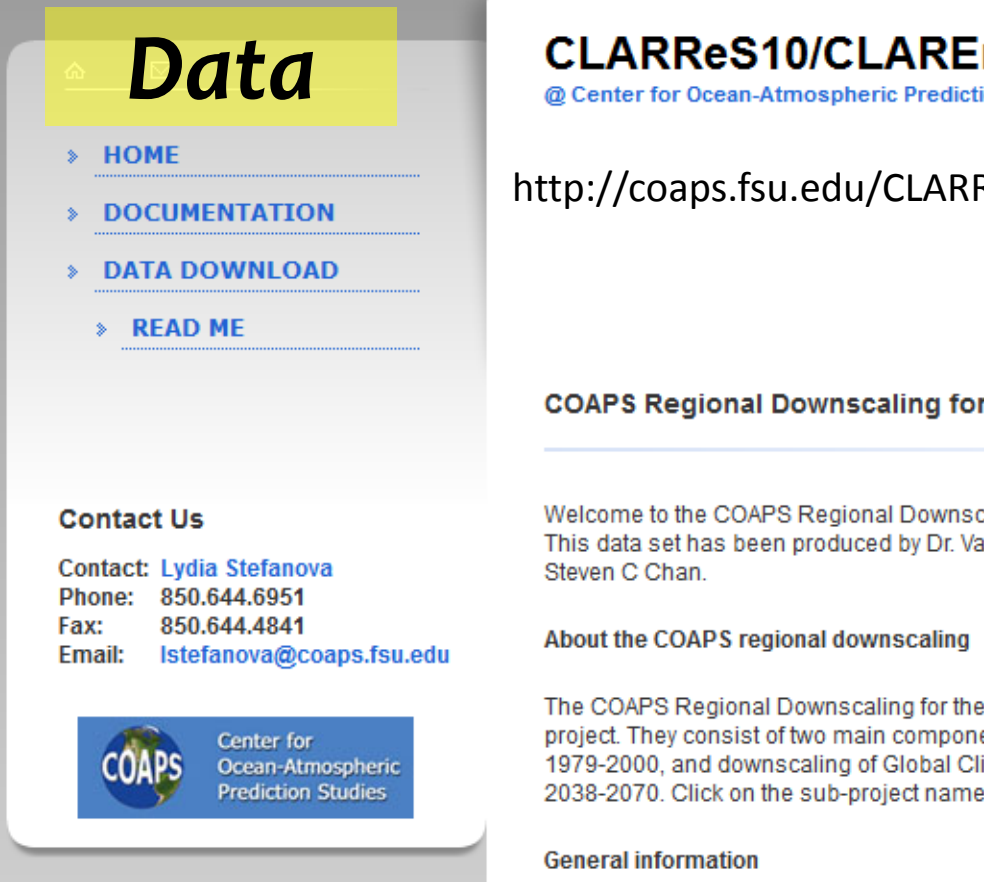
Presentation outline

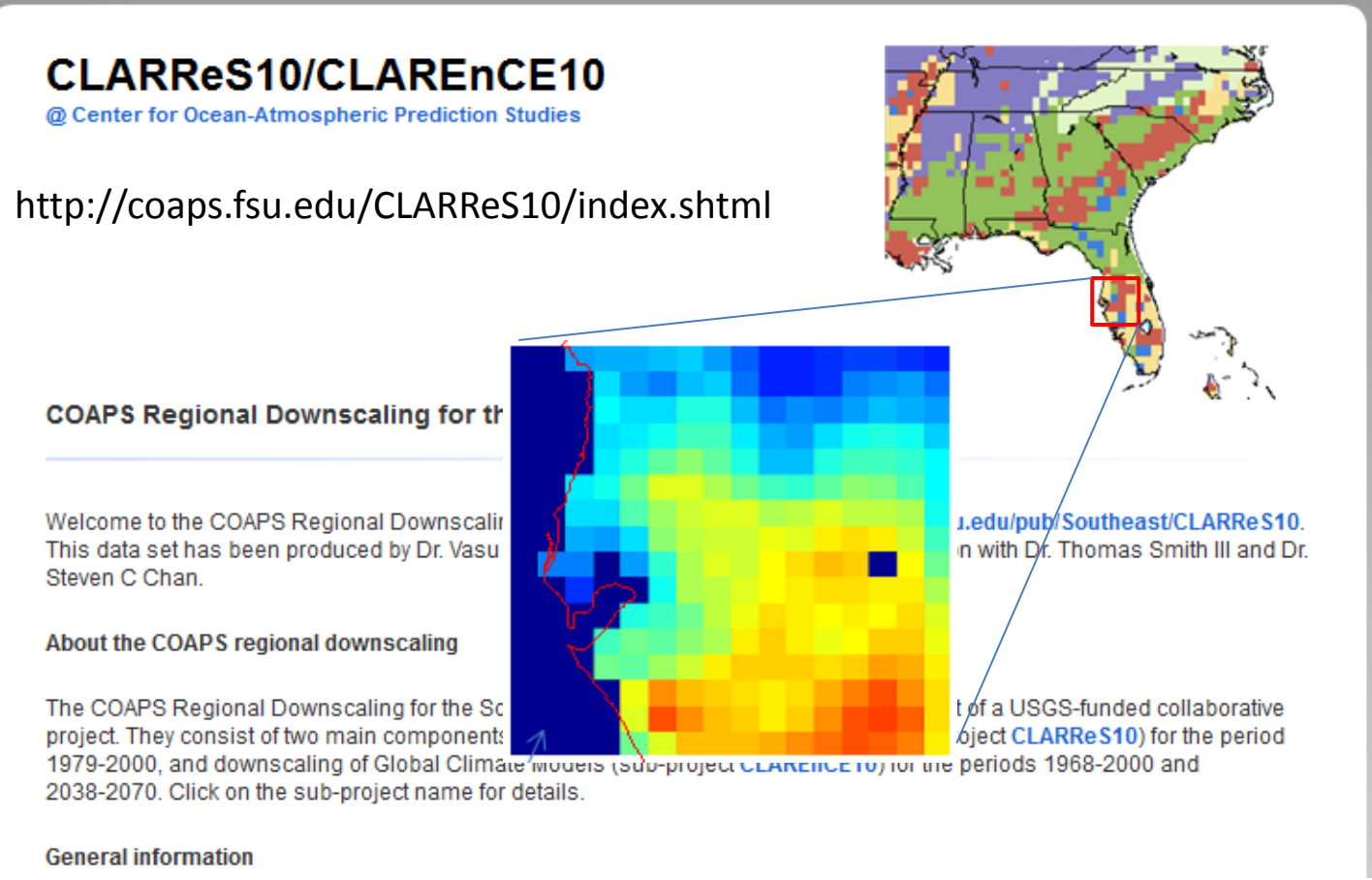
Assessing climate change impact on hydrology using Dynamically downscaled GCMs

- *Data (CLARENCE10)*
  - *3 dynamically downscaled GCMs*
  - *AR4 A2 scenario*
- *bias-correction*
  - *3 Different CDF development methods*
- *Hydrologic modeling*
  - *Integrated Hydrologic Model*
  - *Tampa Bay region, West central Florida*
- *Results I: climate information*
  - *Daily Precipitation*
  - *Daily max. and min. Temperature*
- *Results II: hydrologic implication*
  - *ET estimations*
  - *Mean Streamflow, 7Q10 high/low flow*



Data





- *3 GCMs + Regional Spectral Model (RSM), CCSM, HadCM3, and GFDL*
- *Spatial resolution (10kmx10km) over southeastern US*
- *Variables: hourly Prec., humidity, wind speed, etc., daily Tmax/min data*
  - *Daily bias-corrected Prec. data are available*
- *Retrospective simulation period: 1969-1999*
- *Future simulation (AR4 A2 scenario): 2039-2069*

FLORIDA Water & Climate Alliance

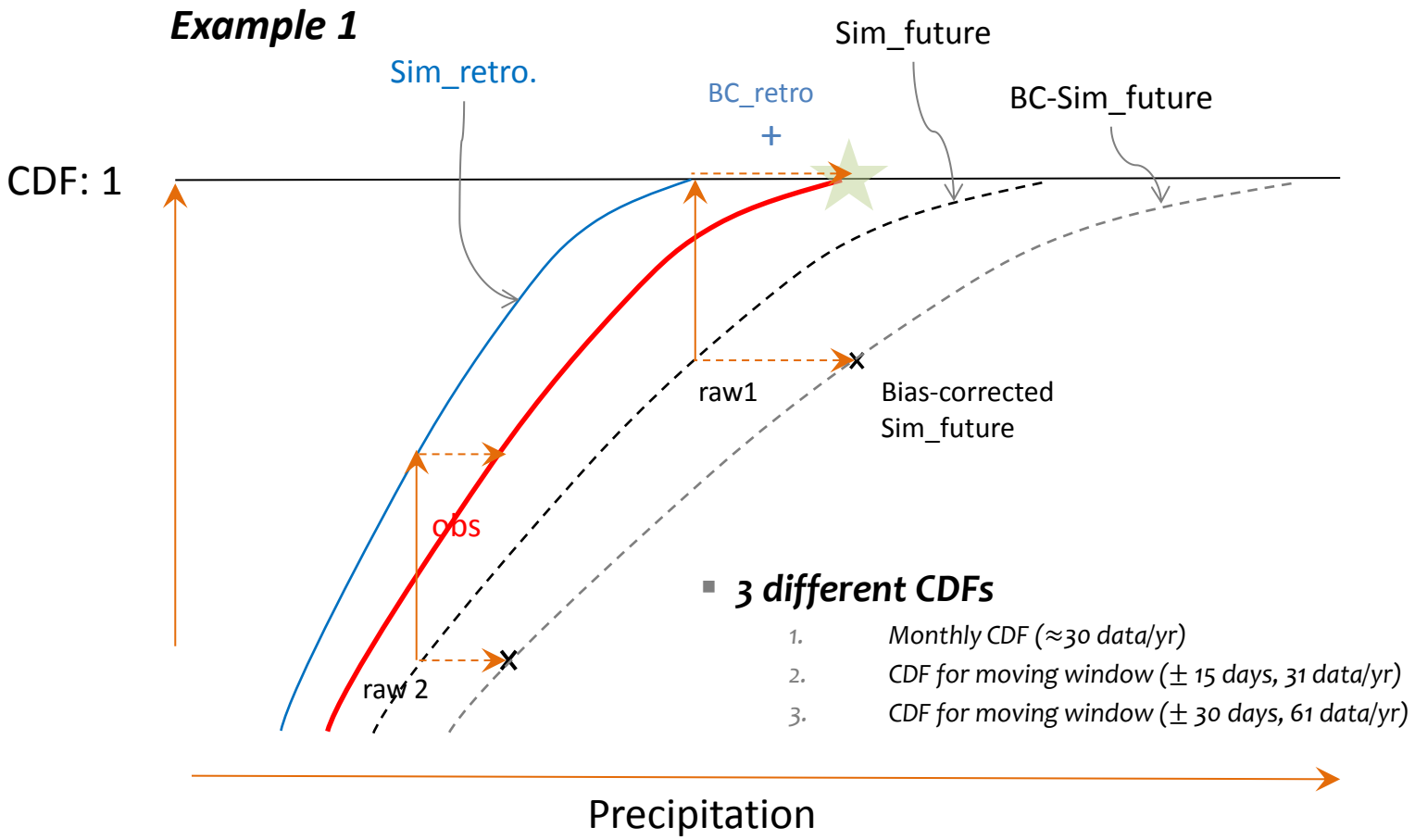
UF Water Institute UNIVERSITY of FLORIDA

NOAA

TAMPA BAY WATER

Bias-correction (BC) Methodology

- *Future Bias Correction methods: CDF mapping*



I. Temperature

- *Spatial distribution of mean temperature*
  (map comparison)

- *Annual cycle of*
  - *Monthly mean Tmax and Tmin*

  - *Differences between the simulations for 1969~1999 & 2039~2069*

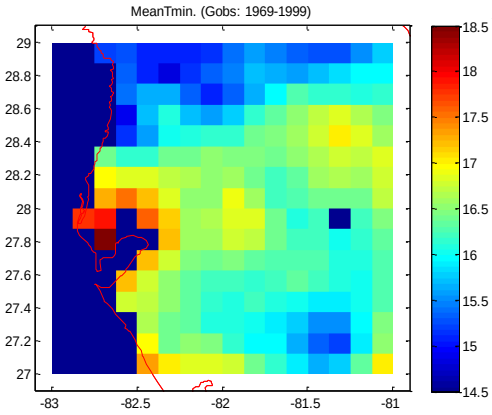
T_{min} spatial distribution

1969~1999

Approx. +2`C =

2039~2069

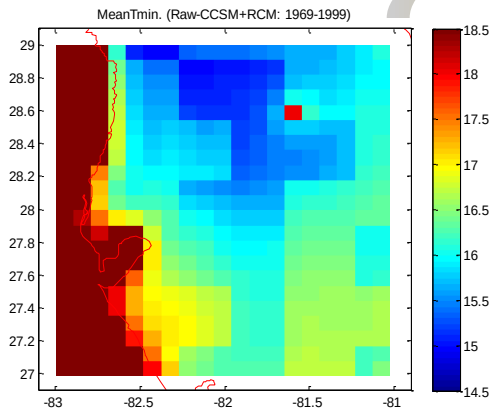
Observation

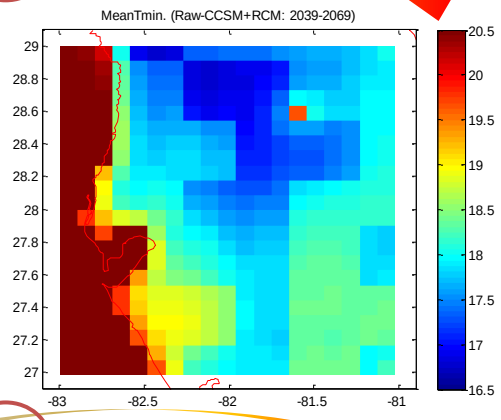


18.5˚C

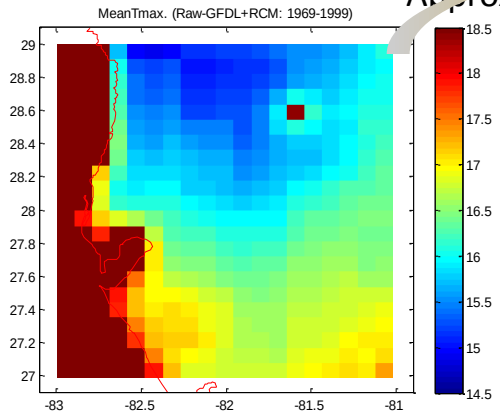
14.5˚C

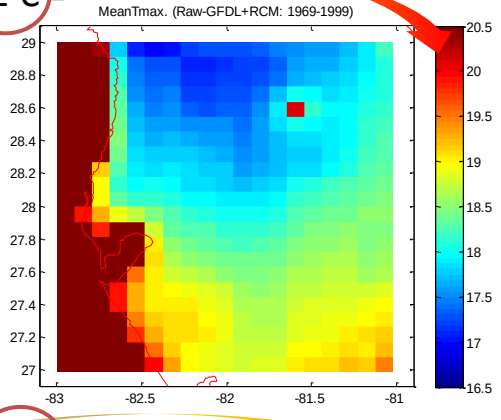
CCSM



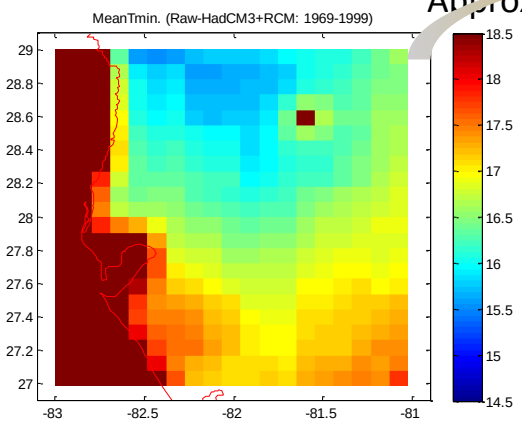


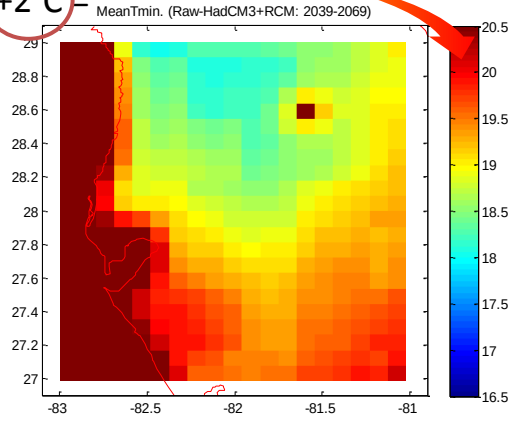
HadCM3





GFDL





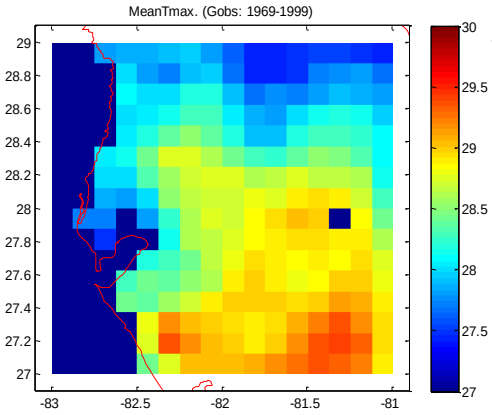
T_{max} spatial distribution

1969~1999

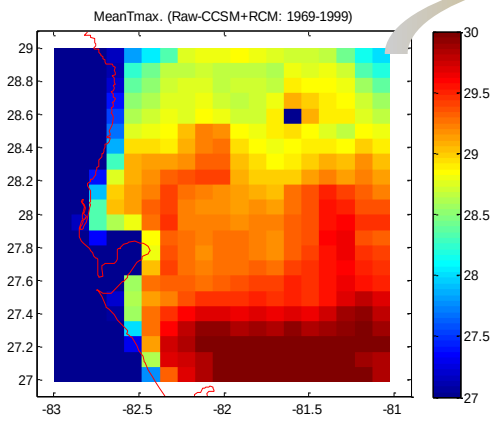
Approx. +3`C =

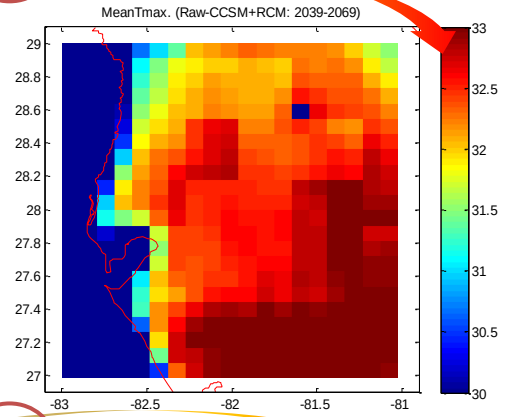
2039~2069

Observation

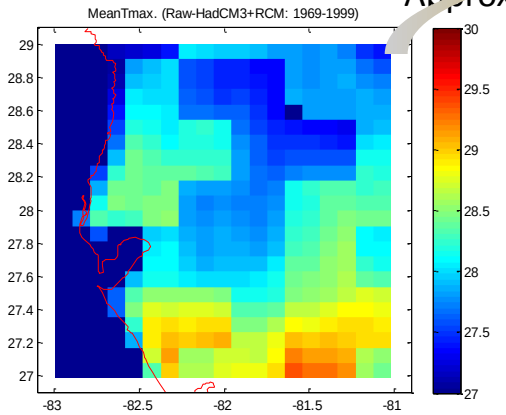


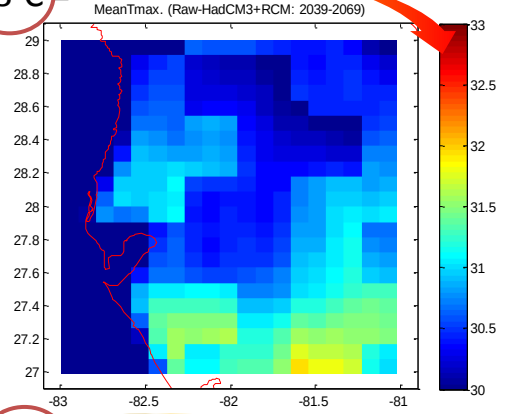
CCSM



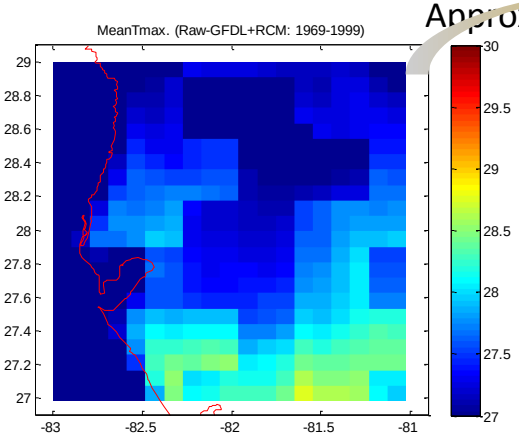


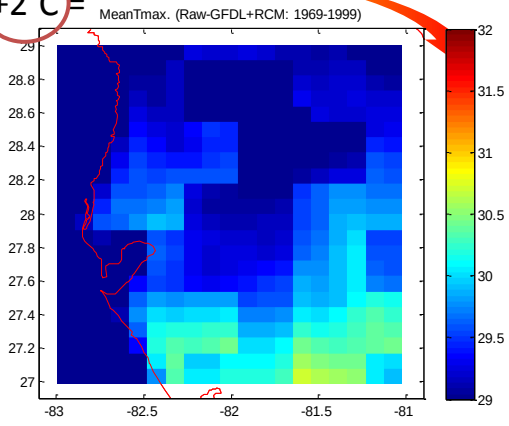
HadCM3



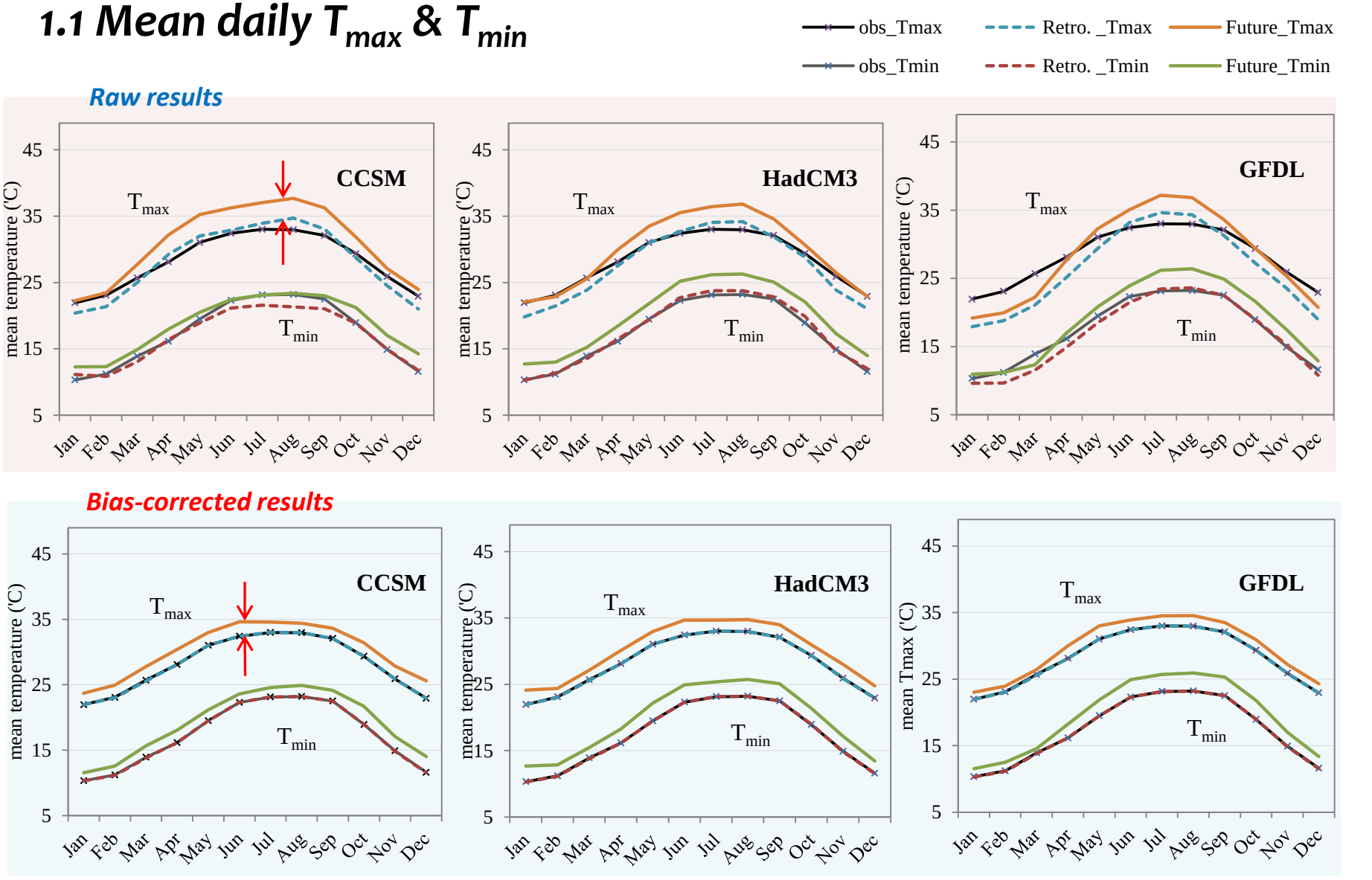


GFDL





1.1 Mean daily T_{max} & T_{min}



Florida Water & Climate Alliance

UF Water Institute UNIVERSITY of FLORIDA

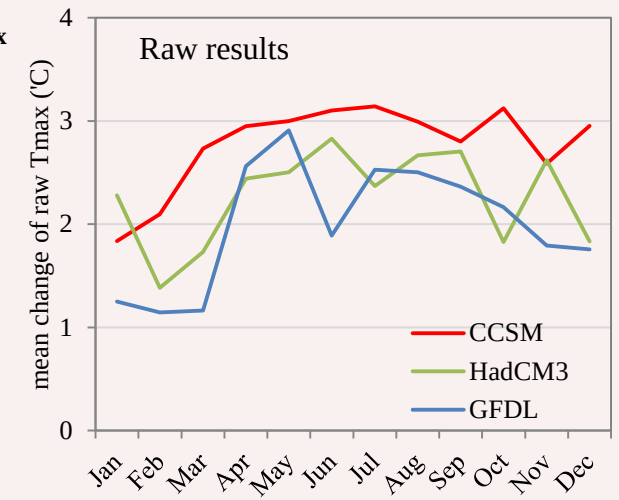
NOAA

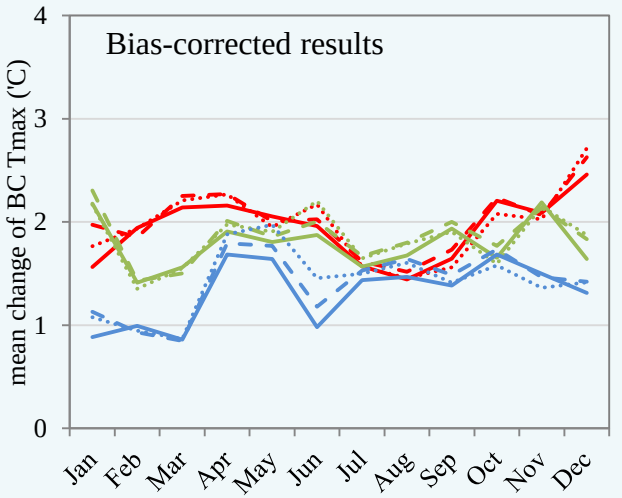
TAMPA BAY WATER

1.2 Mean temperature change: 2039~2069 – 1969~1999

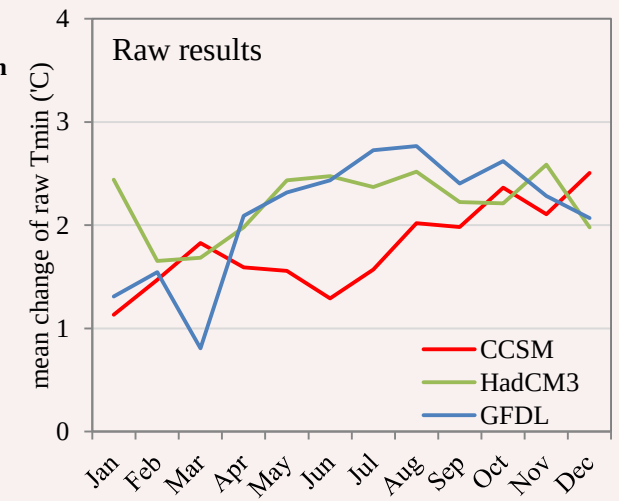
Raw results | **Bias-corrected results**

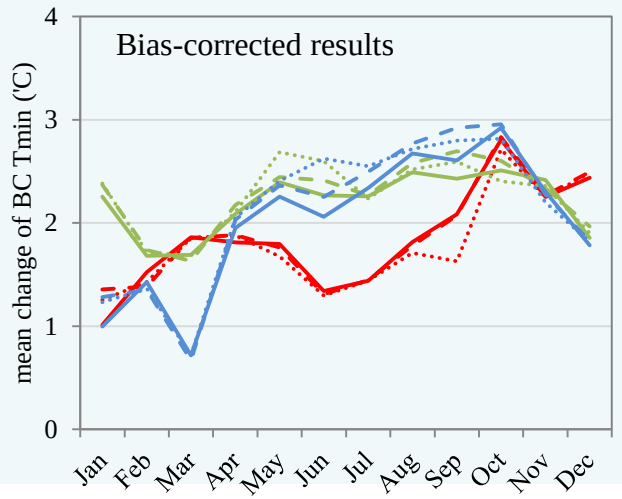
T_{max}





T_{min}





Florida Water & Climate Alliance

UF Water Institute University of Florida

NOAA

Tampa Bay Water

II. Precipitation

- *Spatial distribution of mean precipitation*
  (map comparison)

- *Annual cycle of*
  - *Monthly mean precipitiation*

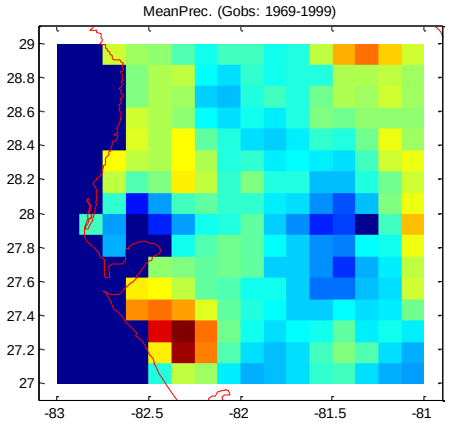
  - *Differences between the simulations for 1969~1999 & 2039~2069*

2.1 Raw Precipitation results

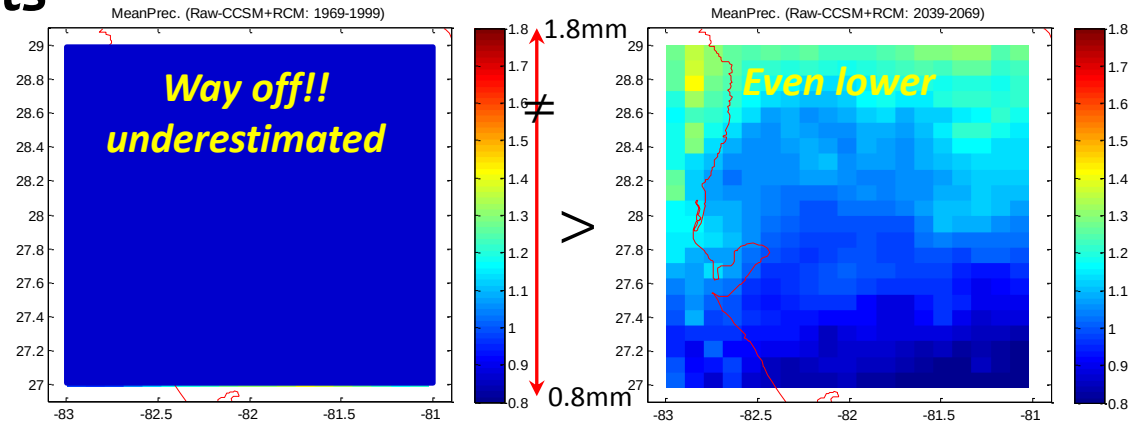
1969~1999

2039~2069

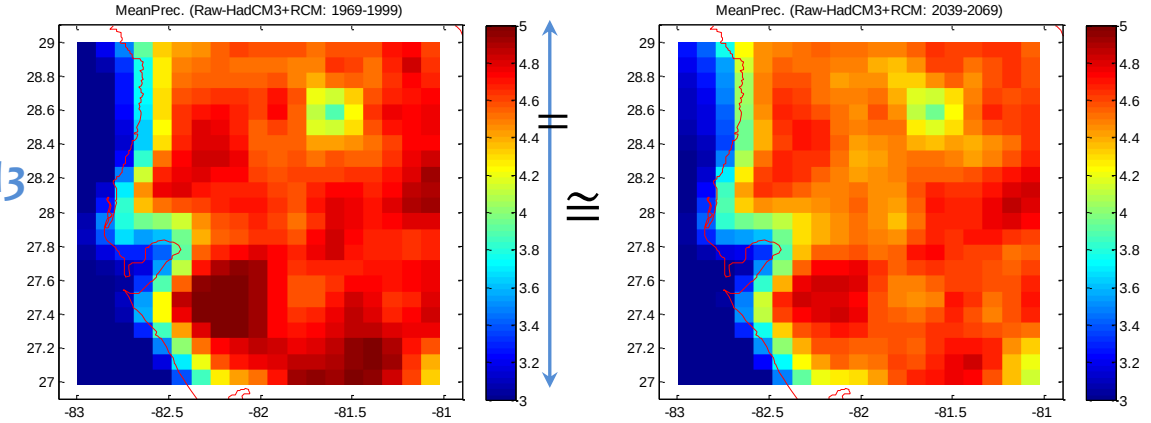
Observation



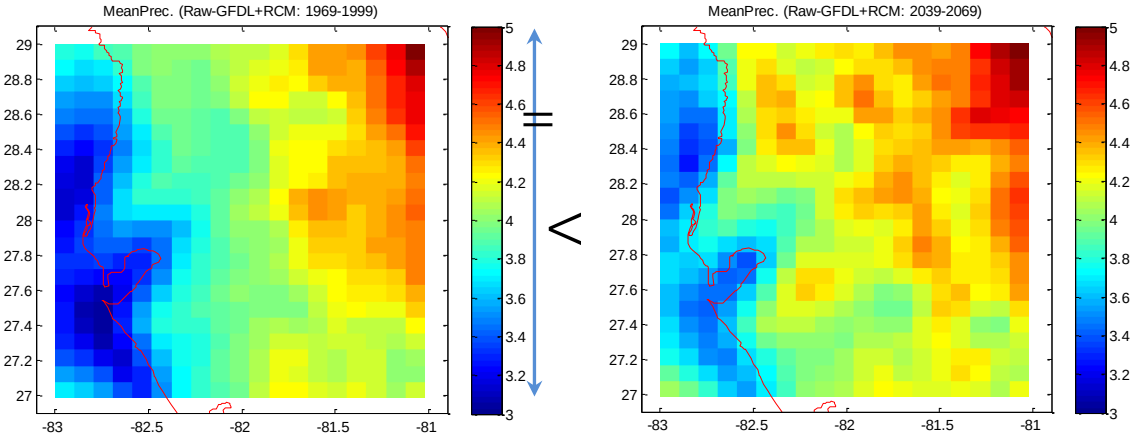
CCSM



HadCM3



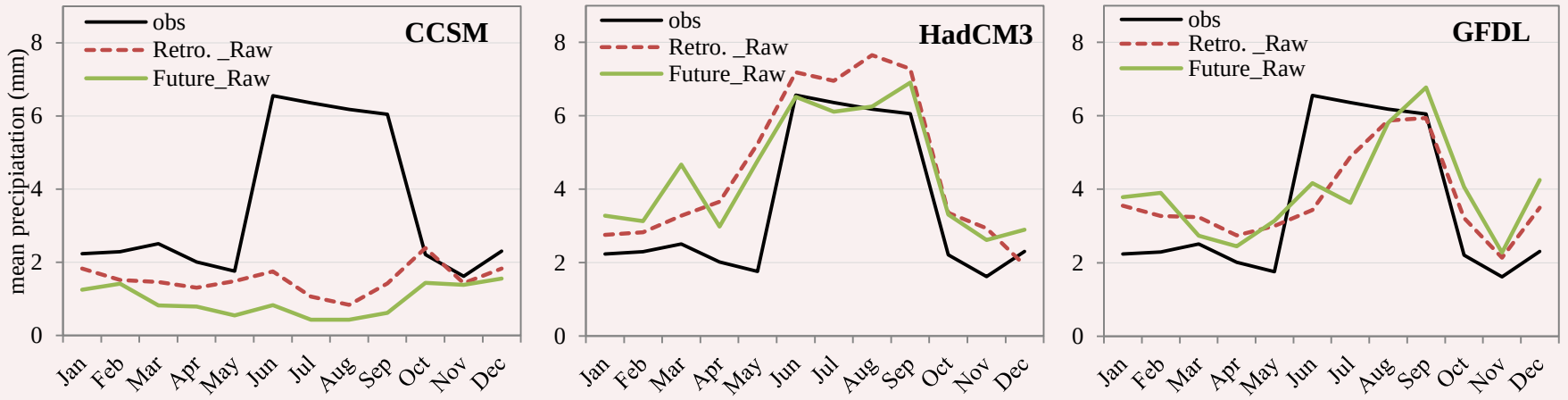
GFDL



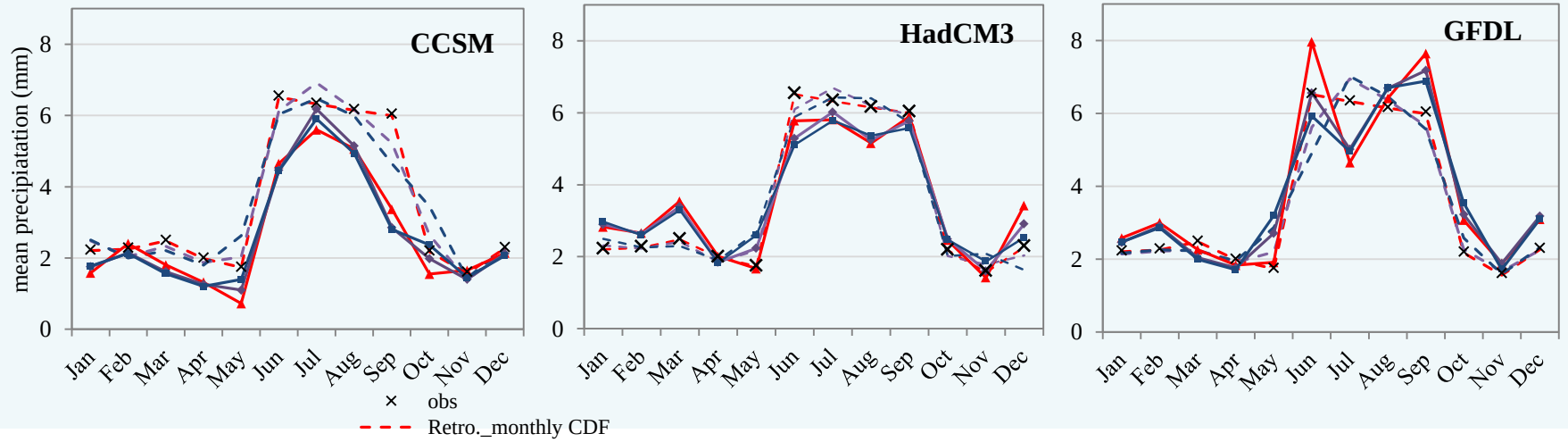
- Raw CCSM results significantly underestimate the mean precp. by 2.5mm over the region
- Raw HadCM3 and GFDL results overestimate by 1~2mm
- Based on the future scenario, precipitation may decrease or increase

2.2 Mean daily precipitation

Raw results



Bias-corrected results



- obs
- Retro._monthly CDF
- Retro._Moving window CDF (±15)
- Retro._Moving window CDF (±30)
- Future_monthly CDF
- Future_Moving window CDF (±15)
- Future_Moving window CDF (±30)

Florida Water & Climate Alliance

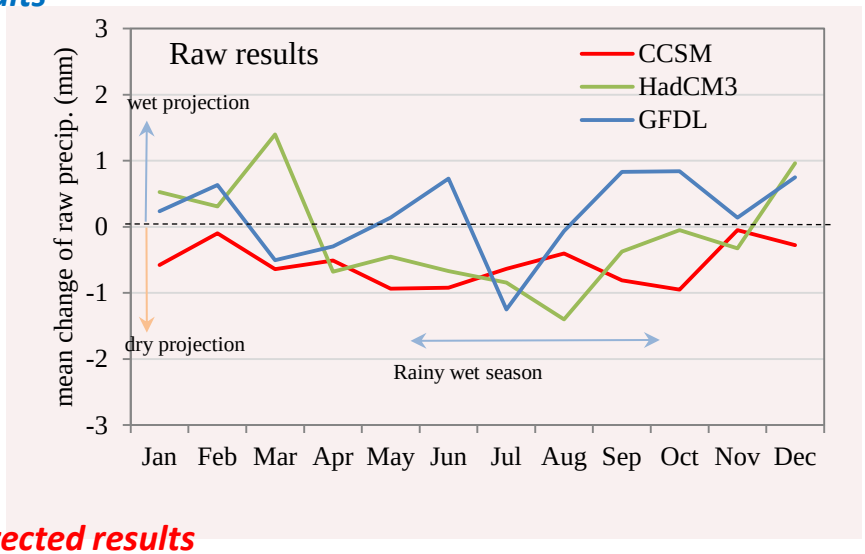
UF Water Institute | University of Florida

NOAA

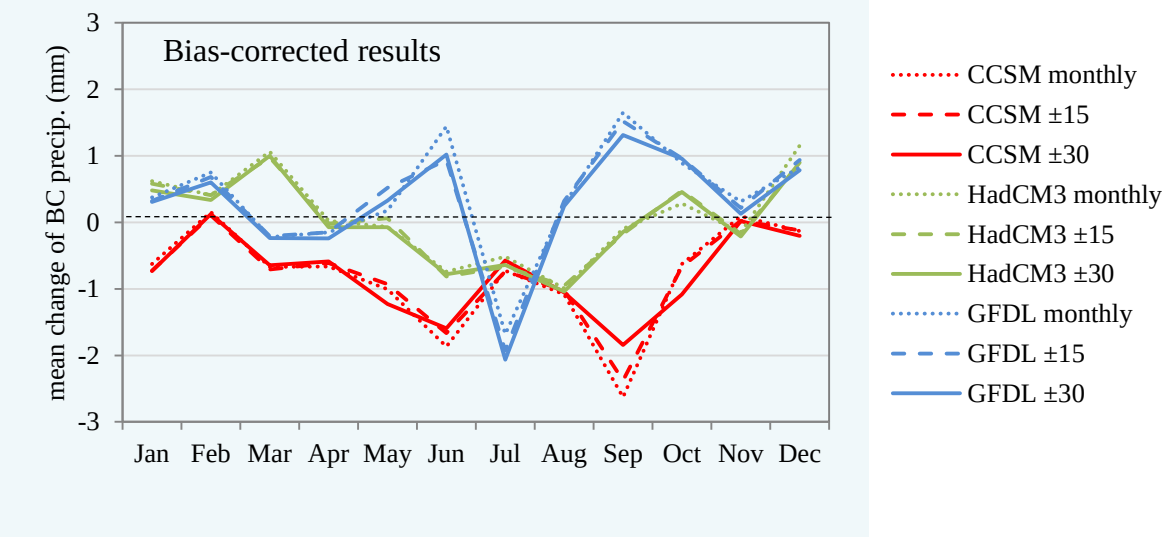
Tampa Bay Water

2.3 Mean precipitation change: 2039~2069 – 1969~1999

Raw results



Bias-corrected results



FLORIDA Water & Climate Alliance

UF Water Institute UNIVERSITY of FLORIDA

NOAA

TAMPA BAY WATER

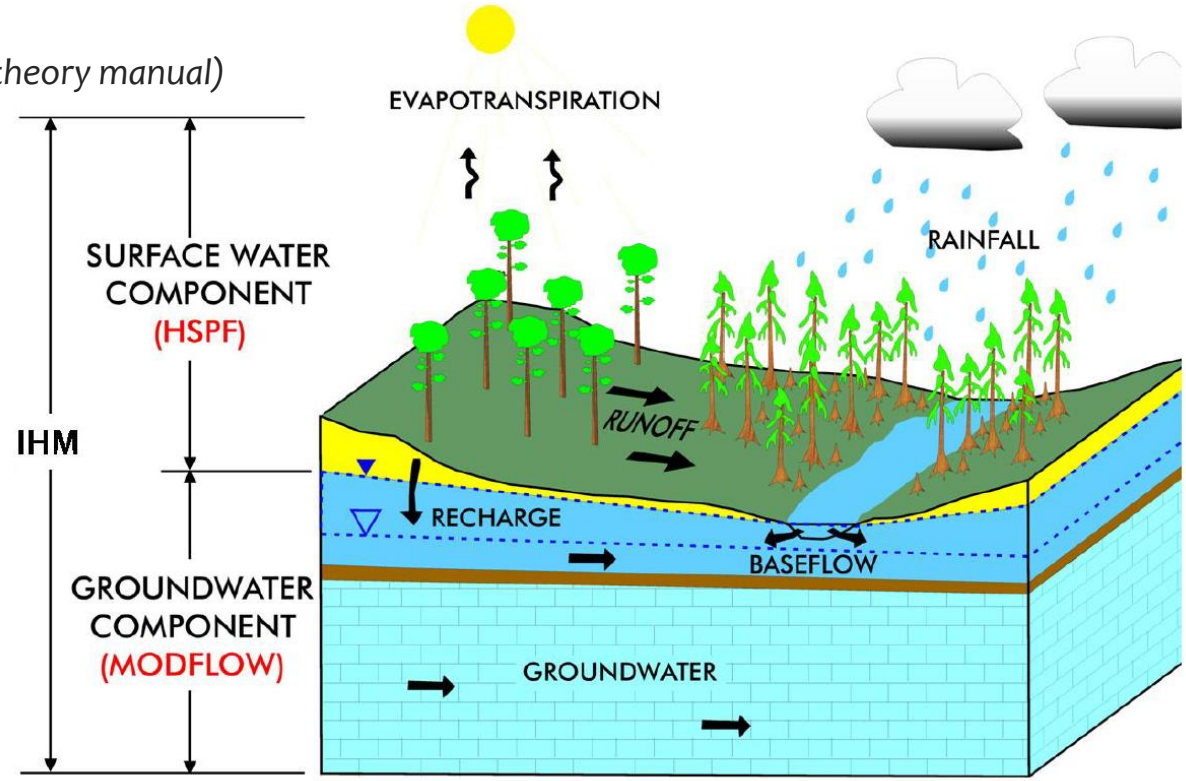
III. Hydrologic implications

- *Annual ET, ET fraction (ET/Precip.)*
- *Mean streamflow*
- *Design flow estimations*

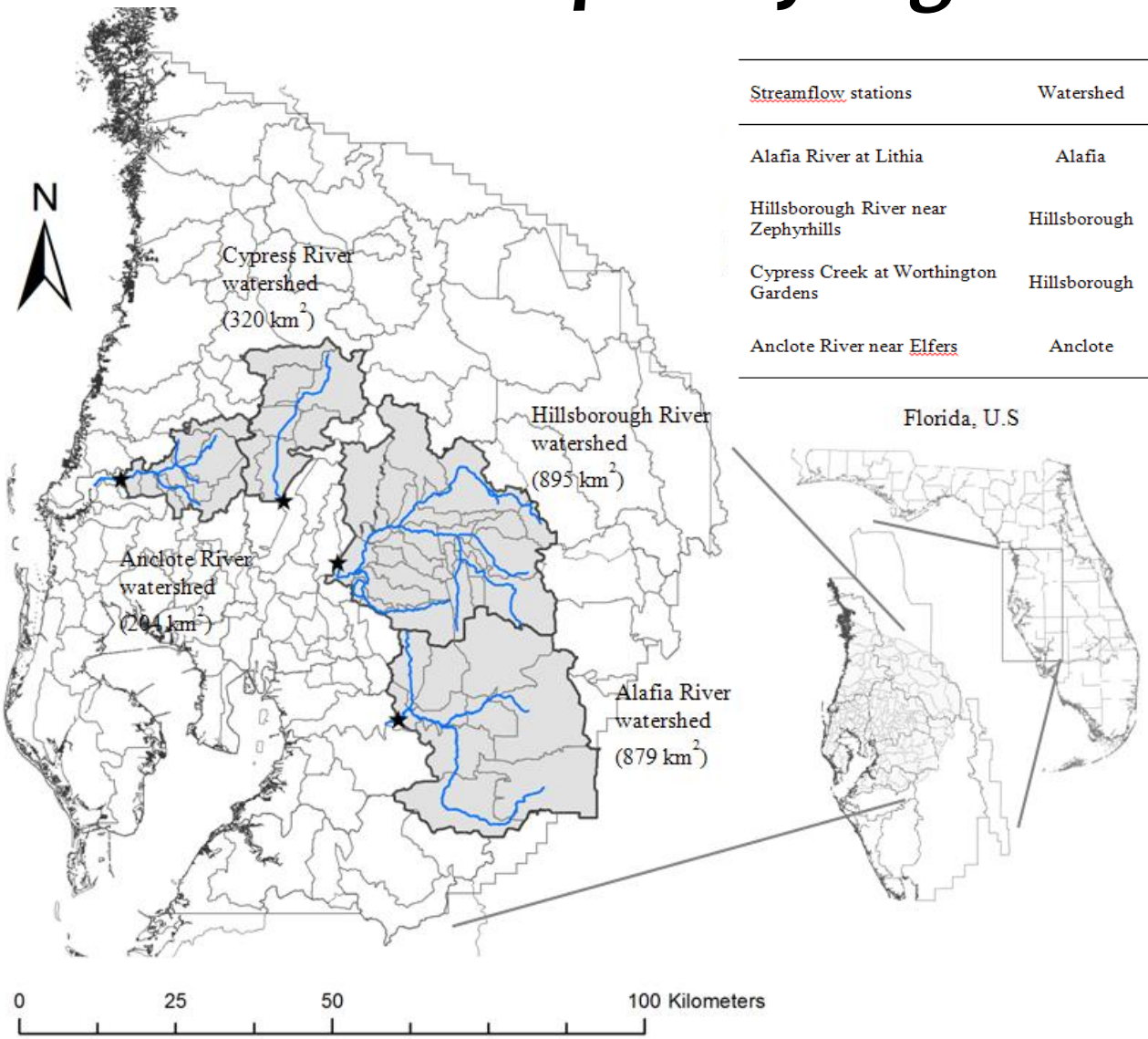
Integrated Hydrologic Model

- *TBW and SWFWMD commissioned the development and application of an integrated surface water/groundwater model for the Tampa Bay Region.*
- *The Integrated Hydrologic Model (IHM) was developed which integrates the EPA Hydrologic Simulation Program-Fortran for surface-water modeling with the US Geological Survey MODFLOW96 for groundwater modeling.*

Ross et al., 2004 (IHM theory manual)



Tampa Bay region



Streamflow stations	Watershed	Latitude	Longitude	Drainage area, (km²)
Alafia River at Lithia	Alafia	27.8719	-82.2114	867.3
Hillsborough River near Zephyrhills	Hillsborough	28.1497	-82.2325	569.6
Cypress Creek at Worthington Gardens	Hillsborough	28.1856	-82.4008	302.9
Anclote River near Elfers	Anclote	28.2139	-82.6667	187.7

FLORIDA Water & Climate Alliance

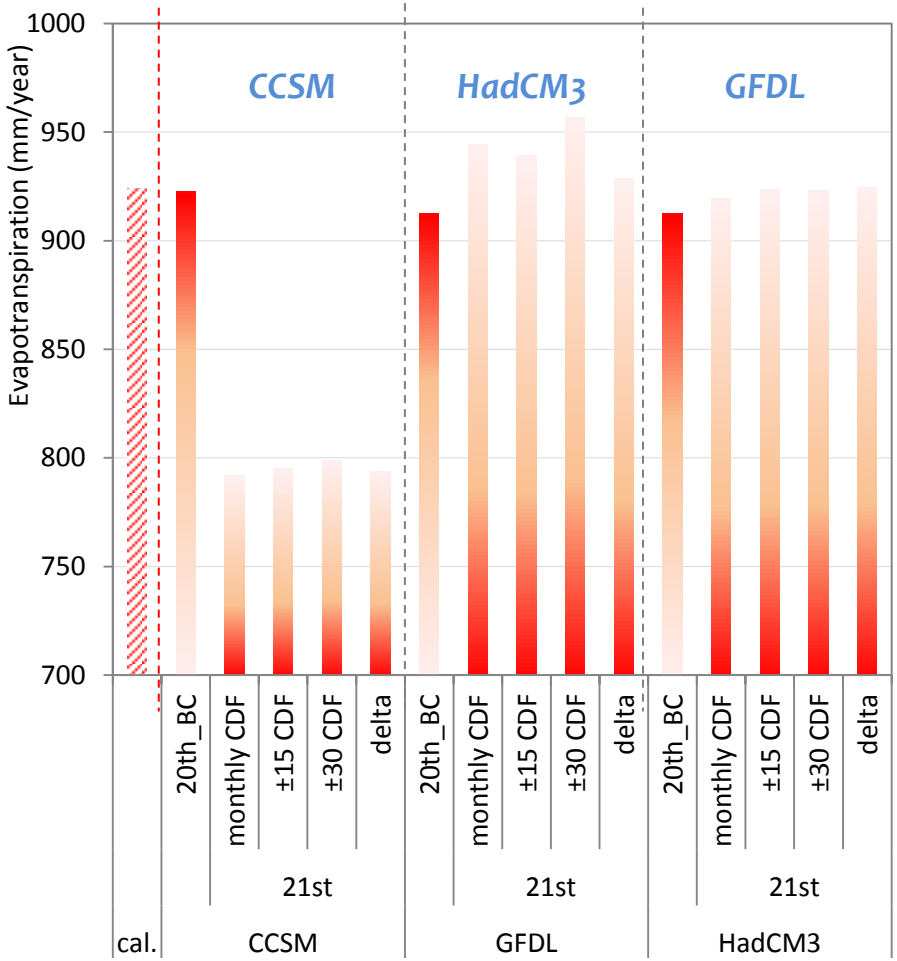
UF Water Institute UNIVERSITY of FLORIDA

NOAA

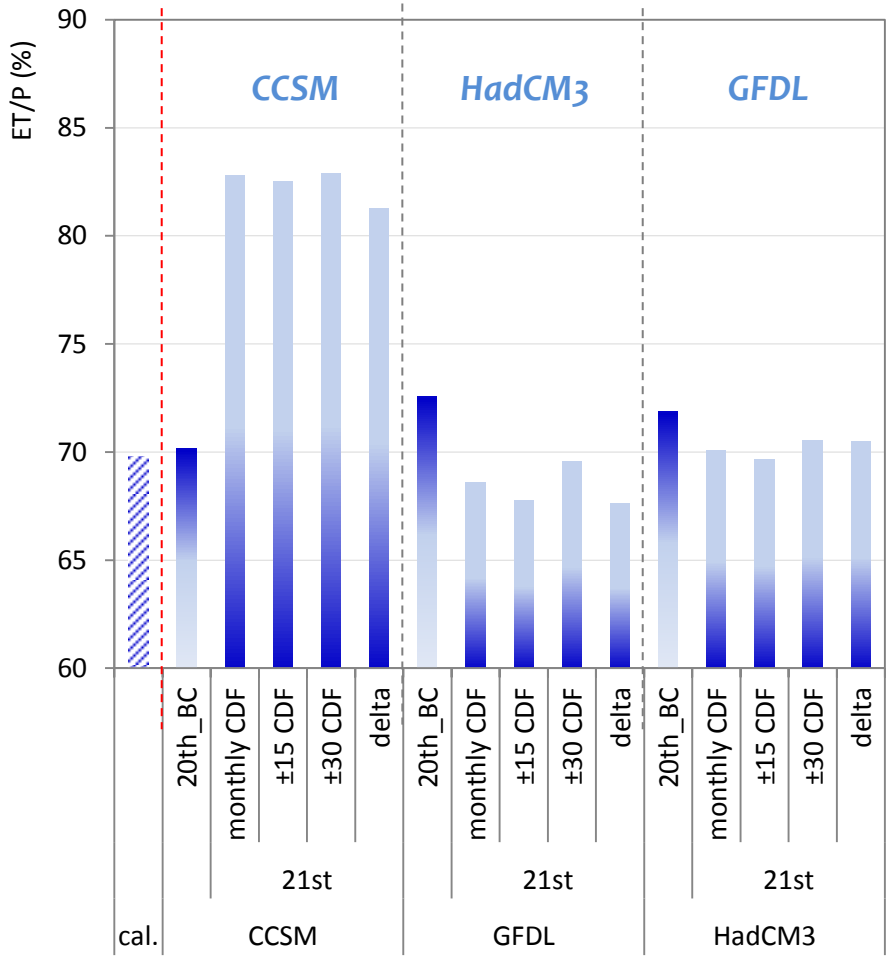
TAMPA BAY WATER

3.1 ET estimations

Annual average ET (mm/year)



ET fraction (ET/Precp.)



Florida Water & Climate Alliance

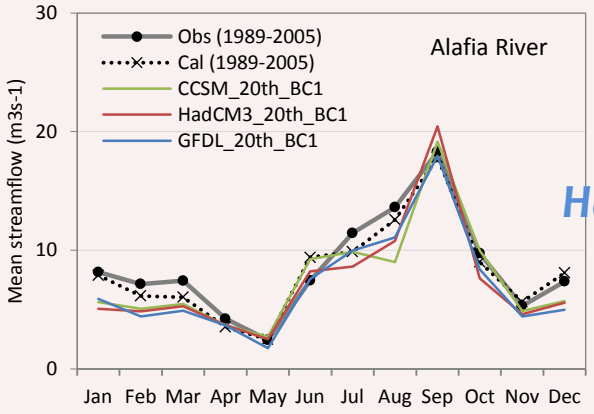
UF Water Institute UNIVERSITY of FLORIDA

NOAA

TAMPA BAY WATER

3.2 mean streamflow
(Alafia River station)

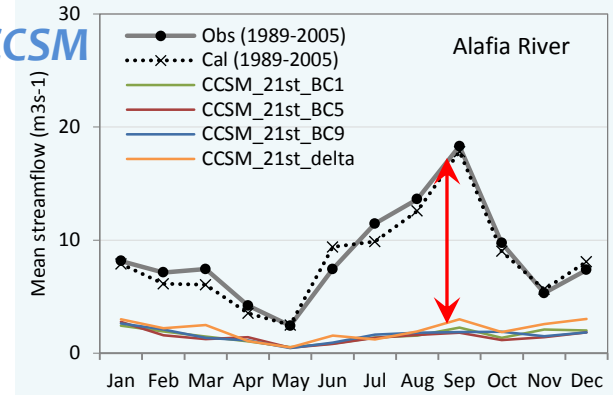
Retrospective simulation results



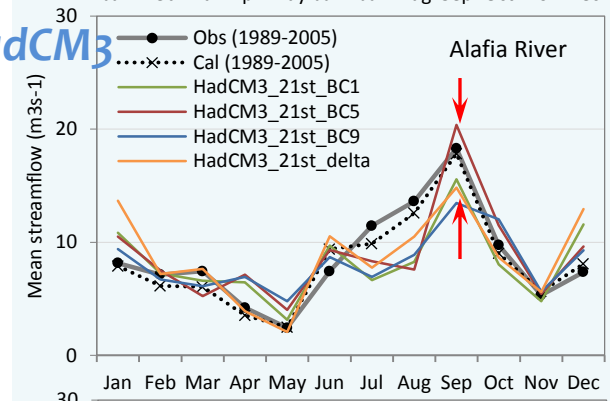
BC1: bias-correction using monthly CDF
BC5: bias-correction using ±15 CDF
BC9: bias-correction using ± 30 CDF

Future simulations

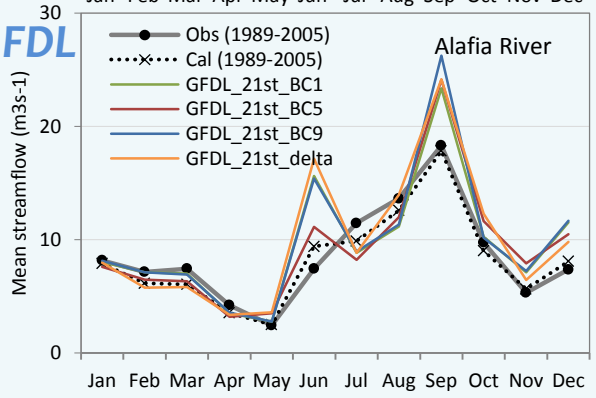
CCSM



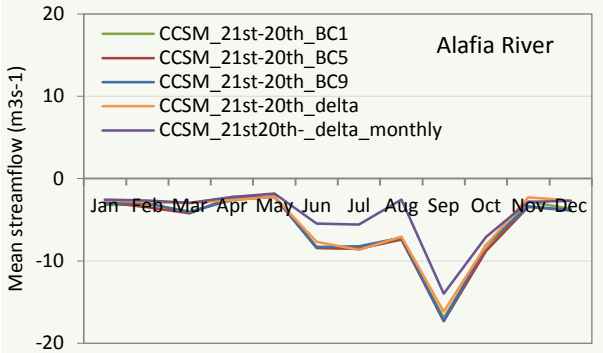
HadCM3

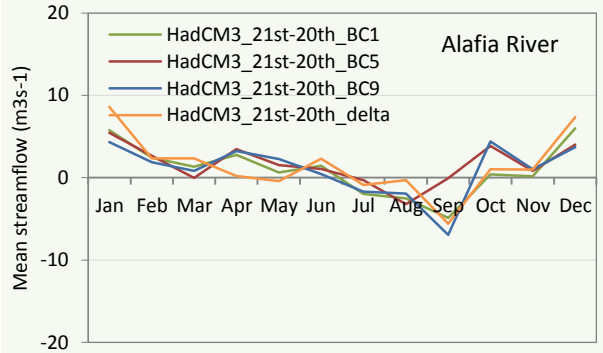


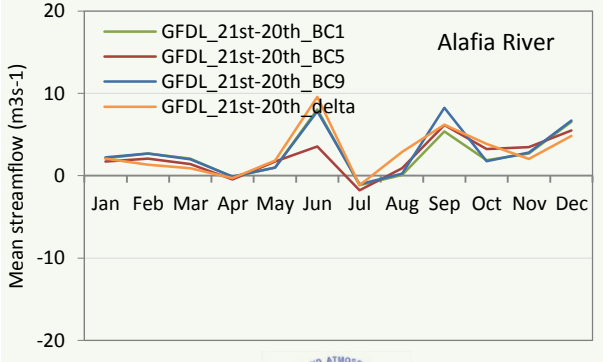
GFDL



Streamflow Change (Future-retro.)







FLORIDA Water & Climate Alliance

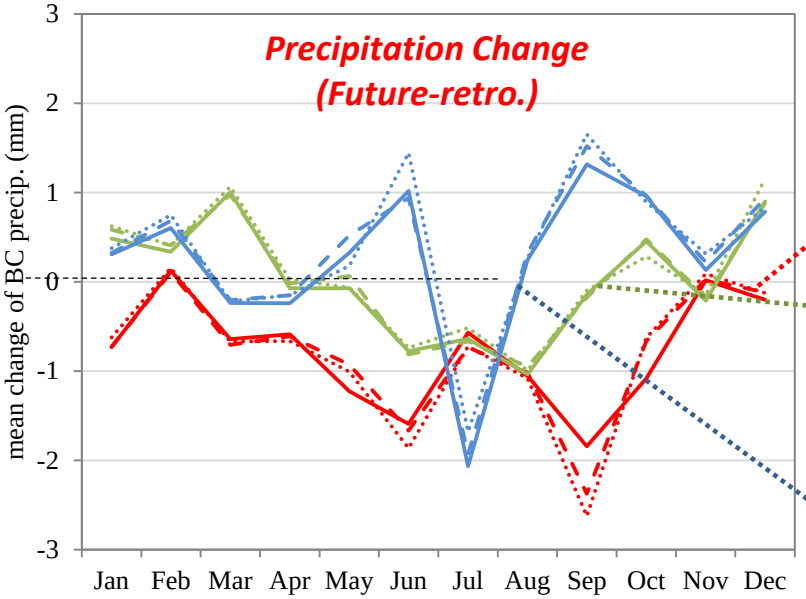
UF Water Institute UNIVERSITY of FLORIDA

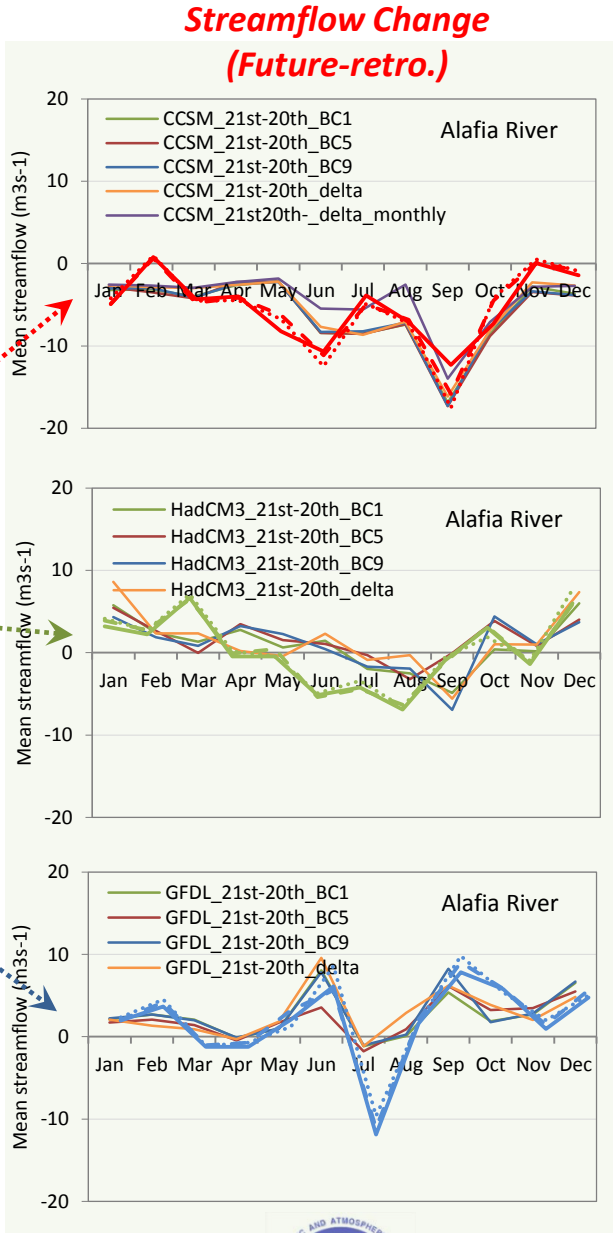
NOAA

TAMPA BAY WATER

3.2 mean streamflow

(Alafia River station)





Florida Water & Climate Alliance

UF Water Institute UNIVERSITY of FLORIDA

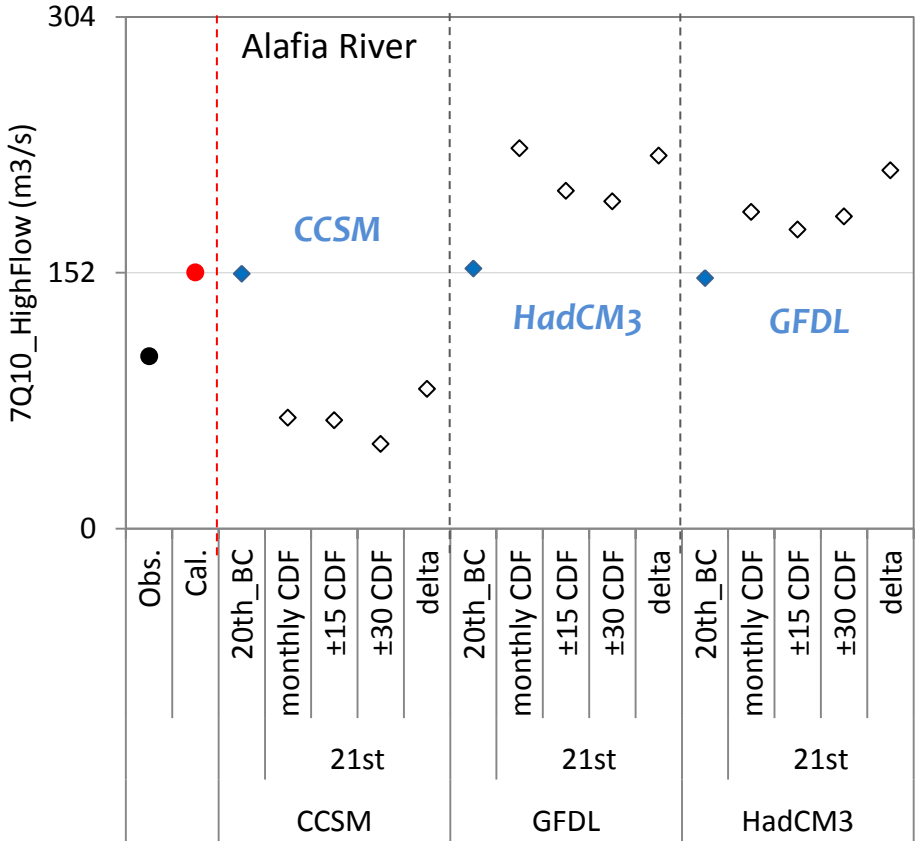
NOAA

TAMPA BAY WATER

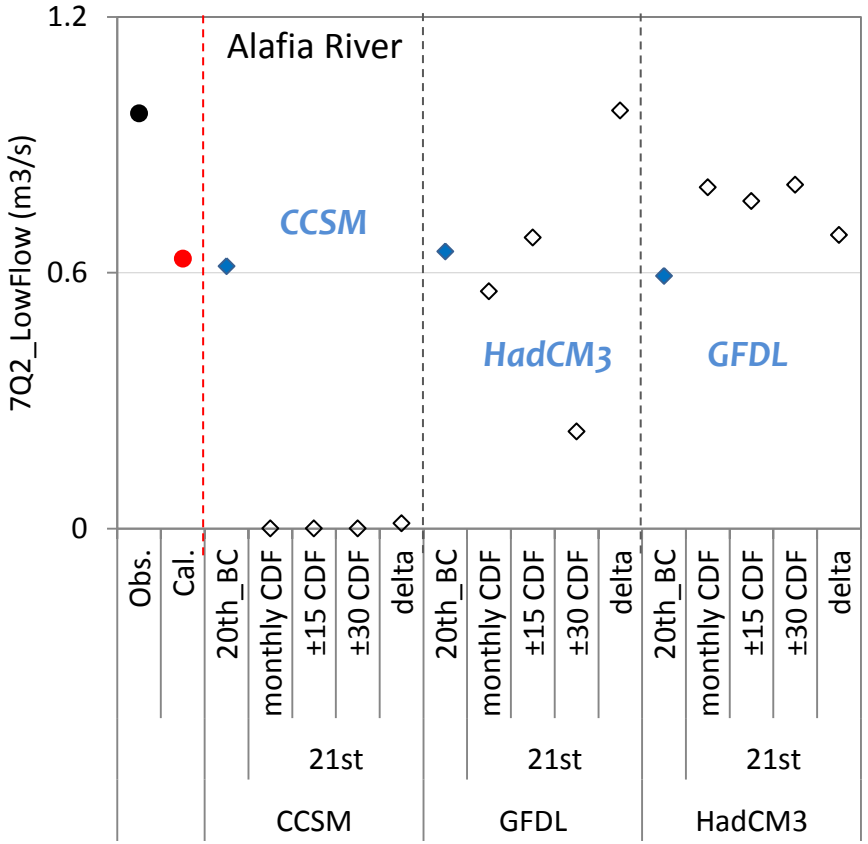
3.3 Design flow estimation

***7Qxx high (low) flow** means the average **maximum (minimum) flow** for seven consecutive days that has probable **recurrence interval of once in xx years,** respectively.*

7Q10 high flow



7Q2 low flow



Florida Water & Climate Alliance

UF Water Institute University of Florida

NOAA

Tampa Bay Water

Conclusions

Used **3 dynamically downscaled GCMs** (i.e., CCSM, Had3CM, GFDL), **3 CDF construction** strategies for CDF mapping bias-correction, and **monthly delta method** for future scenarios

- *Differences among GCM projections overwhelmed differences among bias correction techniques.*
- ***Temperature** Results*
  - *All GCMs successfully reproduced spatial distribution and mean climatology of retrospective daily temperature*
  - *All consistently estimated 2-3^{o}C increase of mean temperature for future (2039~2069) under future A2 scenario.*
- ***Precipitation** Results*
  - *Dynamically downscaled retrospective CCSM predictions are way off!*
  - *Retrospective HadCM3 and GFDL reproduce seasonal cycle of precipitation.(e.g., wet summer)*
  - *Different GCMs produced conflicting precipitation change estimates for future A2 scenarios (some higher, some lower)*

Conclusions continued

- ***Hydrologic implications***
  - *Even with consistent increased temperature estimates, differences among future precipitation estimates propagate into significant differences in future hydrologic predictions (i.e. ET, mean streamflow predictions, and 7Q10 estimates).*
  - *Precipitation signal overwhelms temperature signal in predicting hydrologic implications of projected future changes.*

Q. How many GCMs are required to get an accurate representation of range of possible future precipitation projections and thus range of possible hydrologic change?

Q. Should we continue to use CCSM in our analysis?

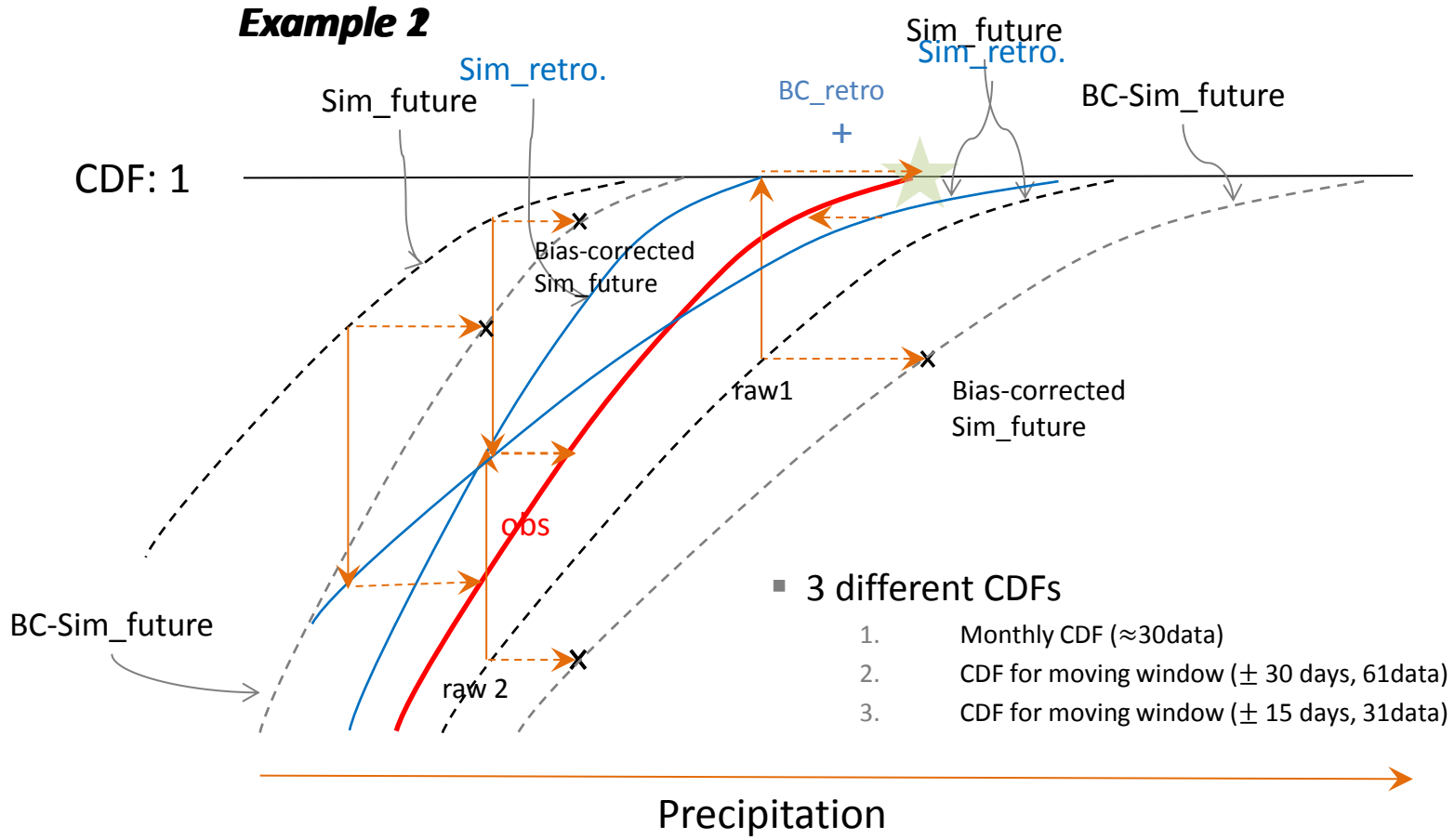
Possible Future Work

- *Consider other climate model products & GHG scenarios…*
  - *NARCCAP, CMIP5, COAPS products, etc.?*
- *Other methodologies to downscale/bias-correct climate model results?*
  - *Statistical downscaling methods in order to increase number of GCMs considered?*
- *For other regions of Florida?*
  - *Using hydrologic models from other agencies*

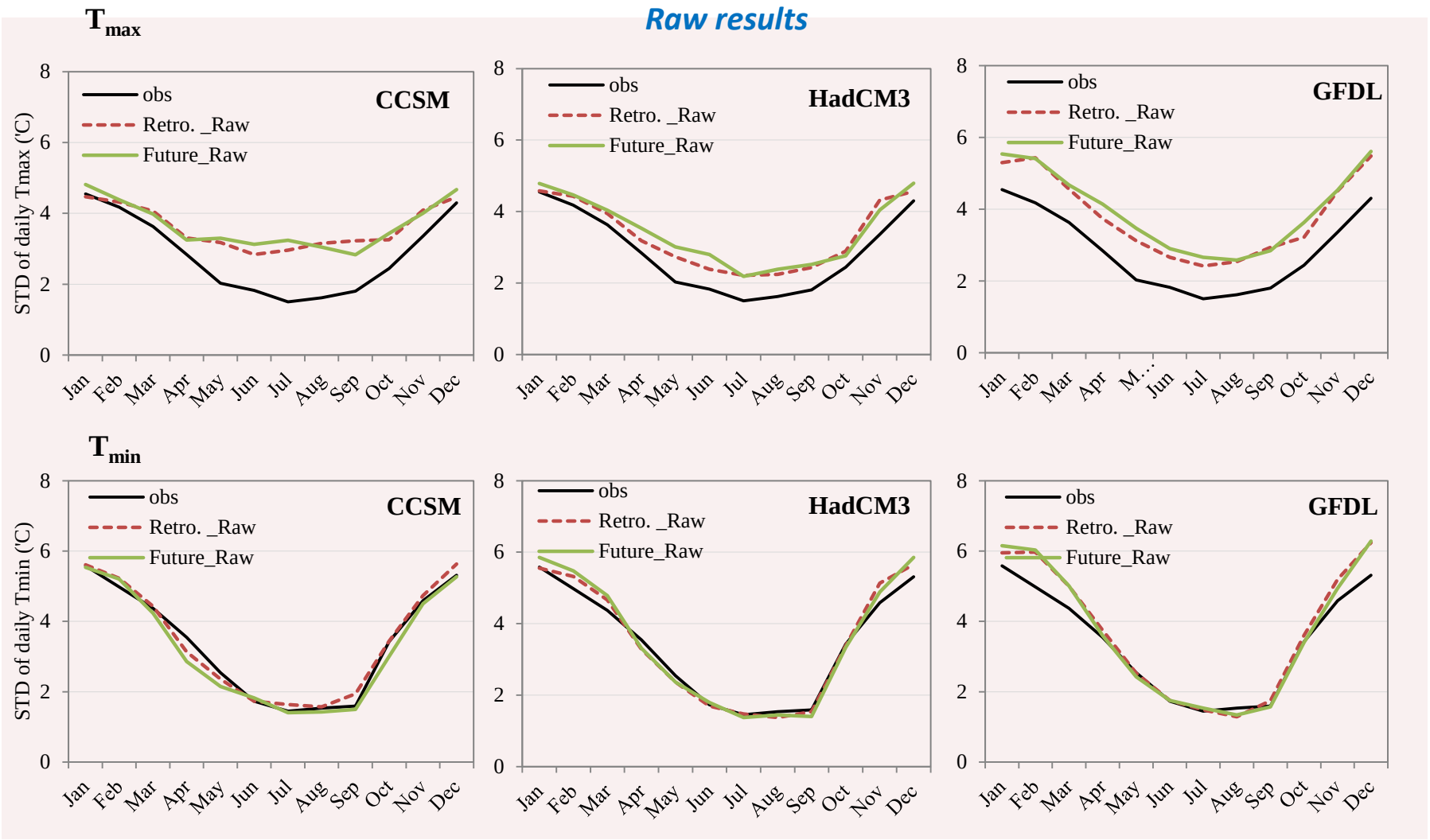
Supplements

Bias-correction (BC) Methodology

- *Future Bias Correction methods: CDF mapping*



1.3 Standard deviation (Stdev.) of daily T_{max} & T_{min}



Florida Water & Climate Alliance

UF Water Institute University of Florida

NOAA

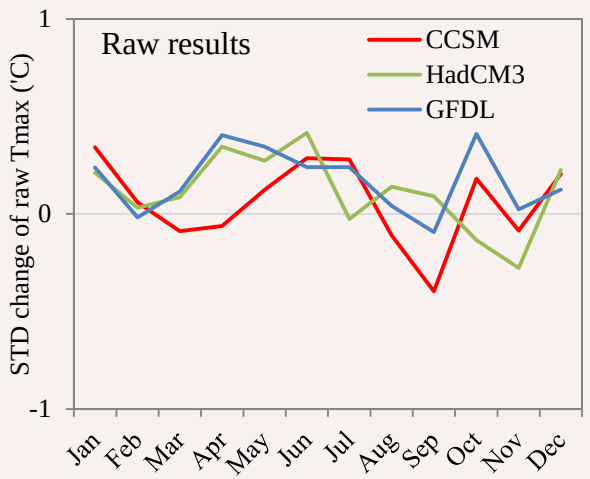
Tampa Bay Water

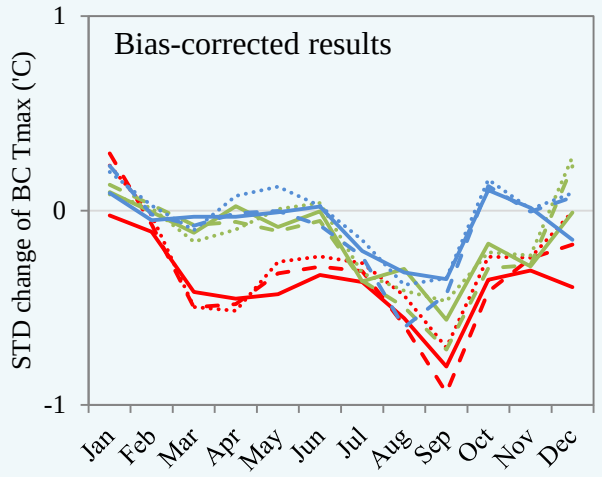
1.4 Mean change of Stdev. : 2039~2069 – 1969~1999

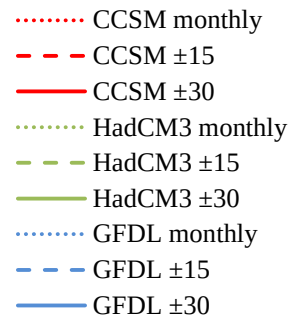
Raw results

Bias-corrected results

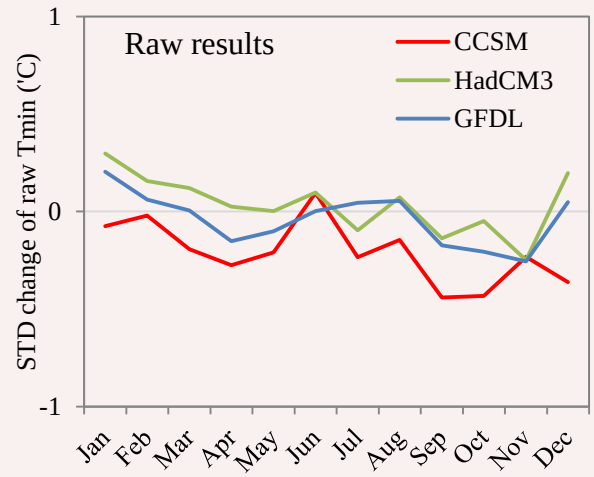
T_{max}

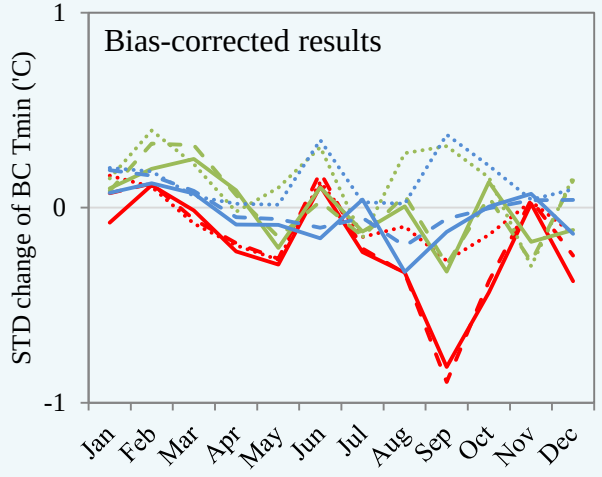


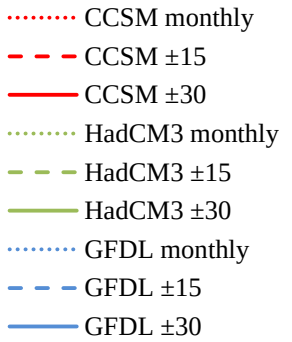




T_{min}







Florida Water & Climate Alliance

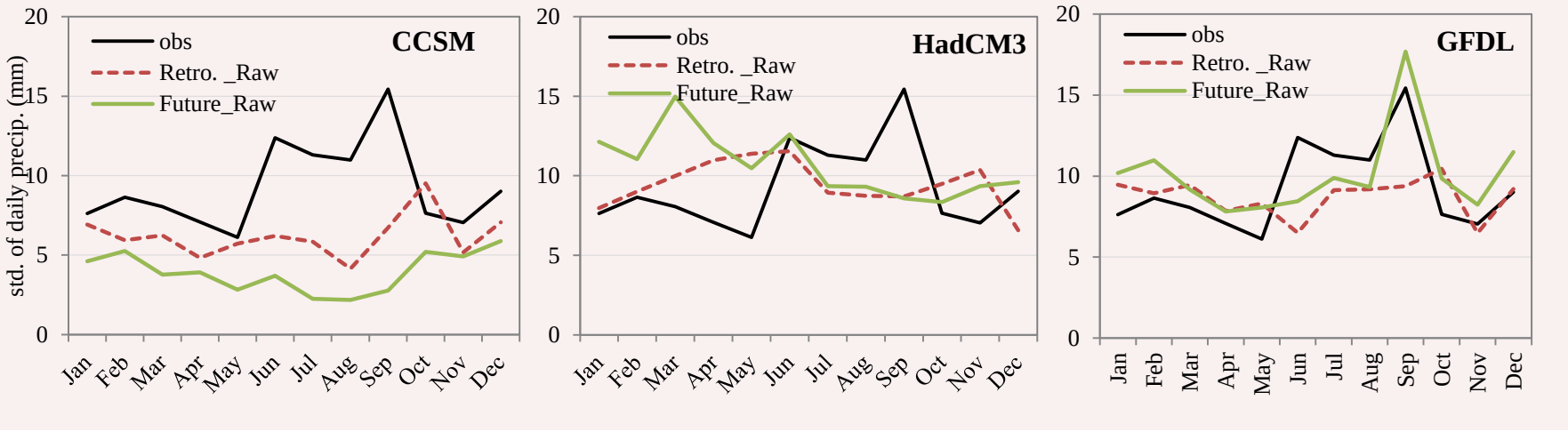
UF Water Institute UNIVERSITY of FLORIDA

NOAA

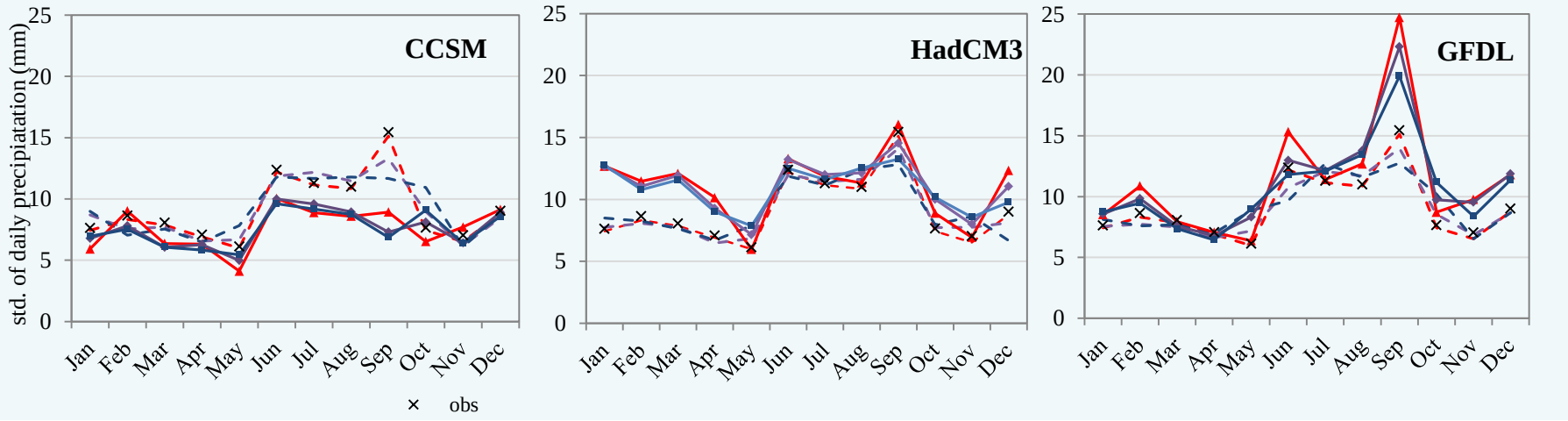
Tampa Bay Water

2.2 Stdev. of daily precipitation

Raw results



Bias-corrected results



Florida Water & Climate Alliance

UF Water Institute UNIVERSITY of FLORIDA

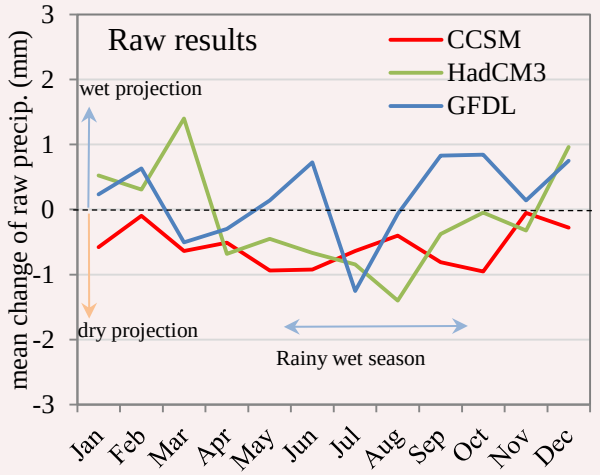
NOAA

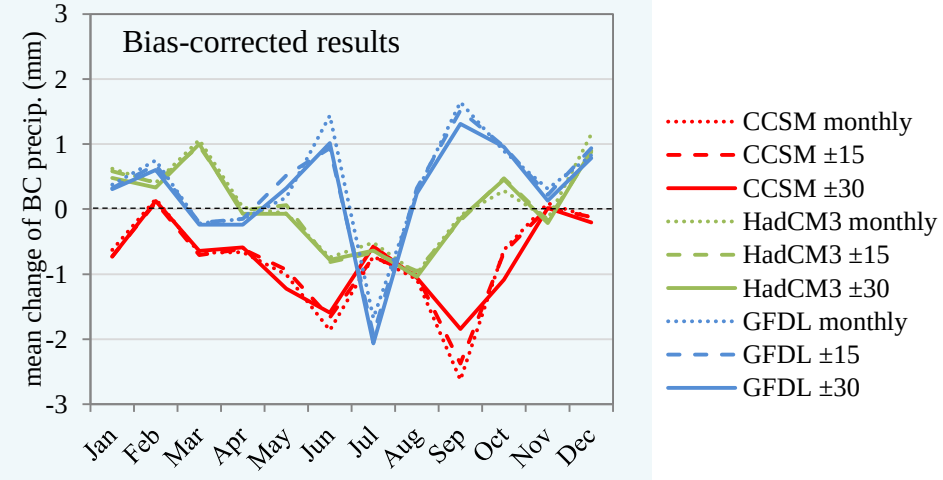
TAMPA BAY WATER

2.3 Precipitation change: 2039~2069 – 1969~1999

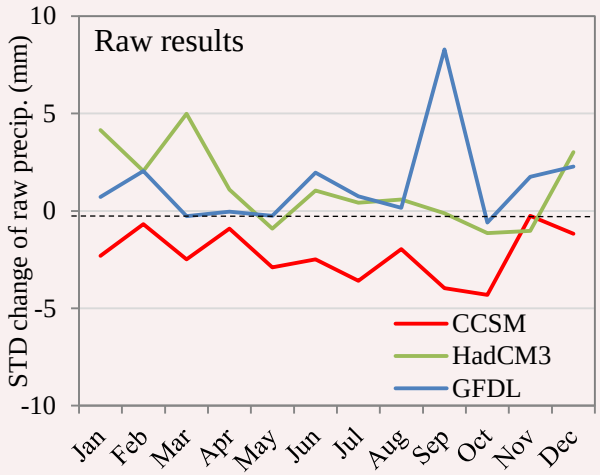
Raw results | **Bias-corrected results**

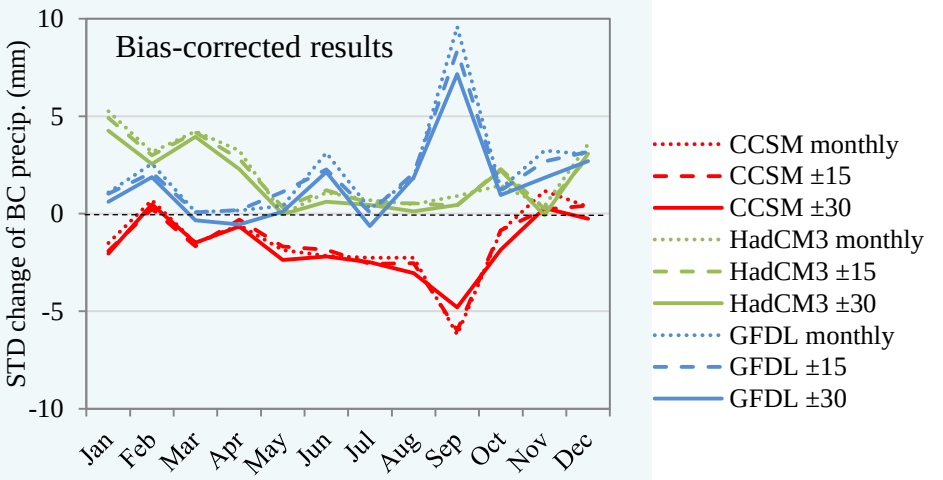
Mean change





Stdev. change





Florida Water & Climate Alliance

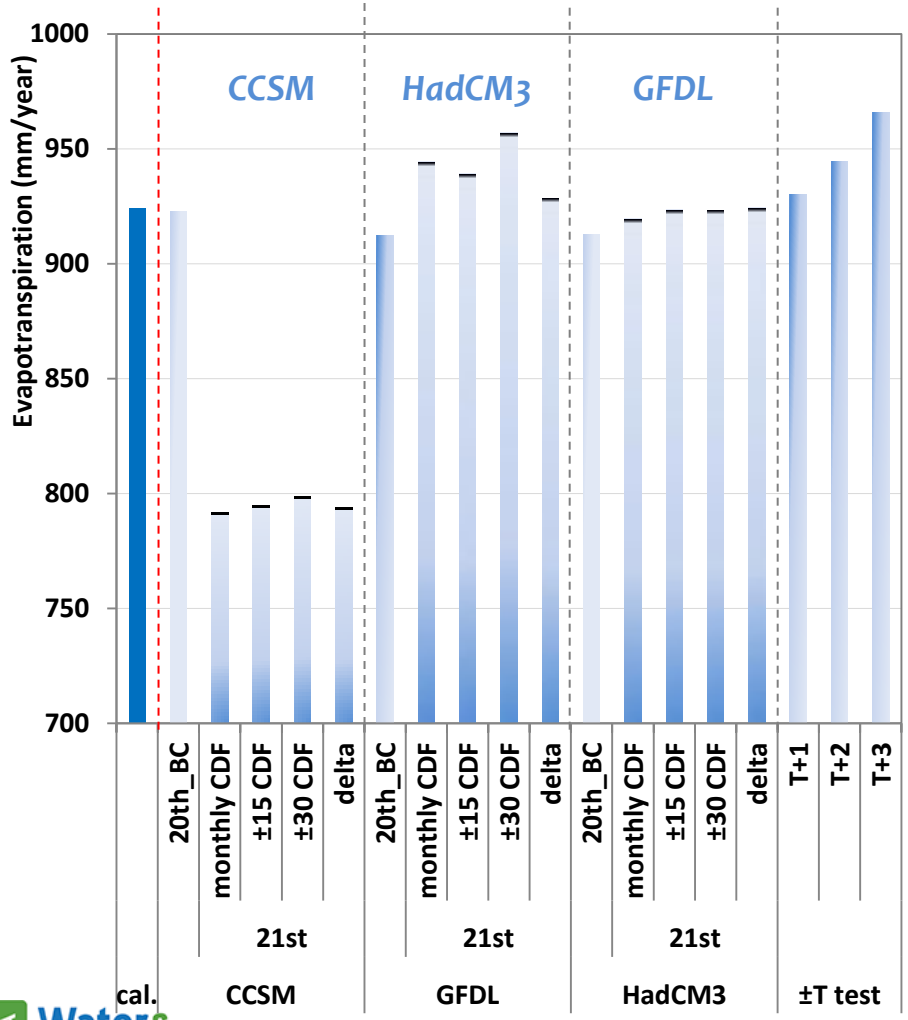
UF Water Institute University of Florida

NOAA

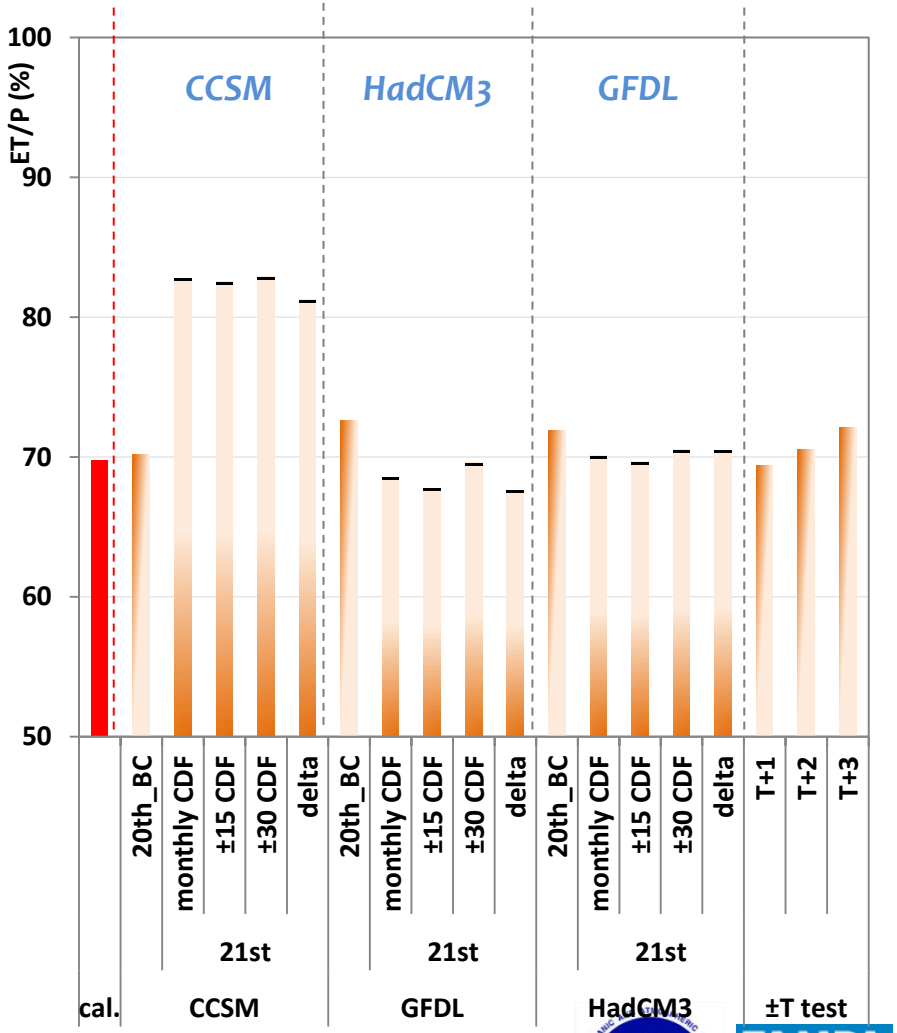
Tampa Bay Water

3.1 ET estimations

Annual average ET (mm/year)



ET rate (ET/Precp.)



FLORIDA Water & Climate Alliance

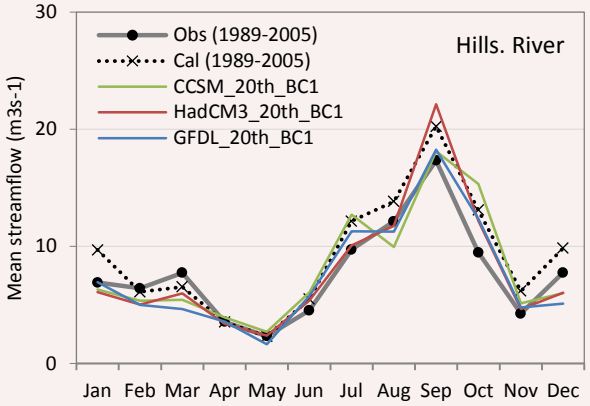
UF Water Institute UNIVERSITY of FLORIDA

NOAA

TAMPA BAY WATER

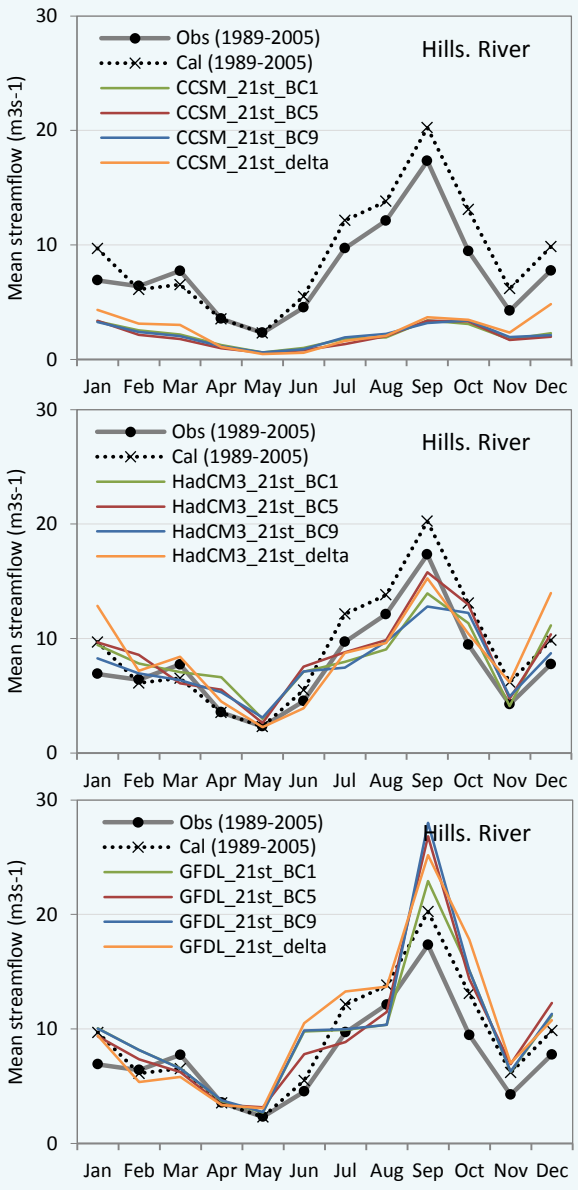
3.2 mean streamflow
(Hillsborough River station)

Retrospective simulation results

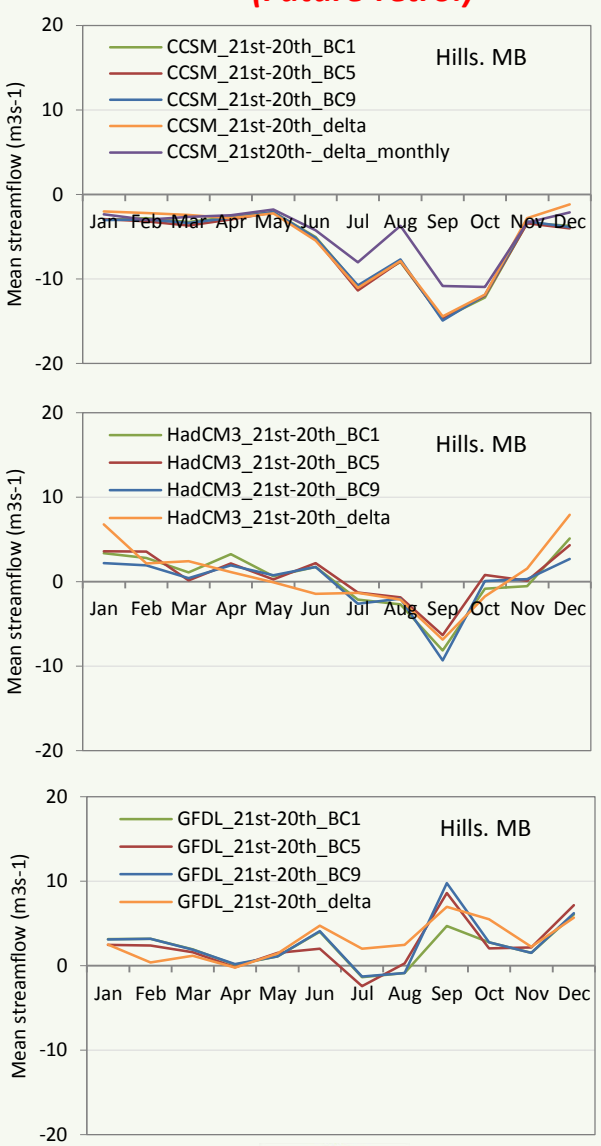


BC1: bias-correction using monthly CDF
BC1: bias-correction using ±15 CDF
BC1: bias-correction using ± 30 CDF

Future simulations



Streamflow Change (Future-retro.)



Florida Water & Climate Alliance

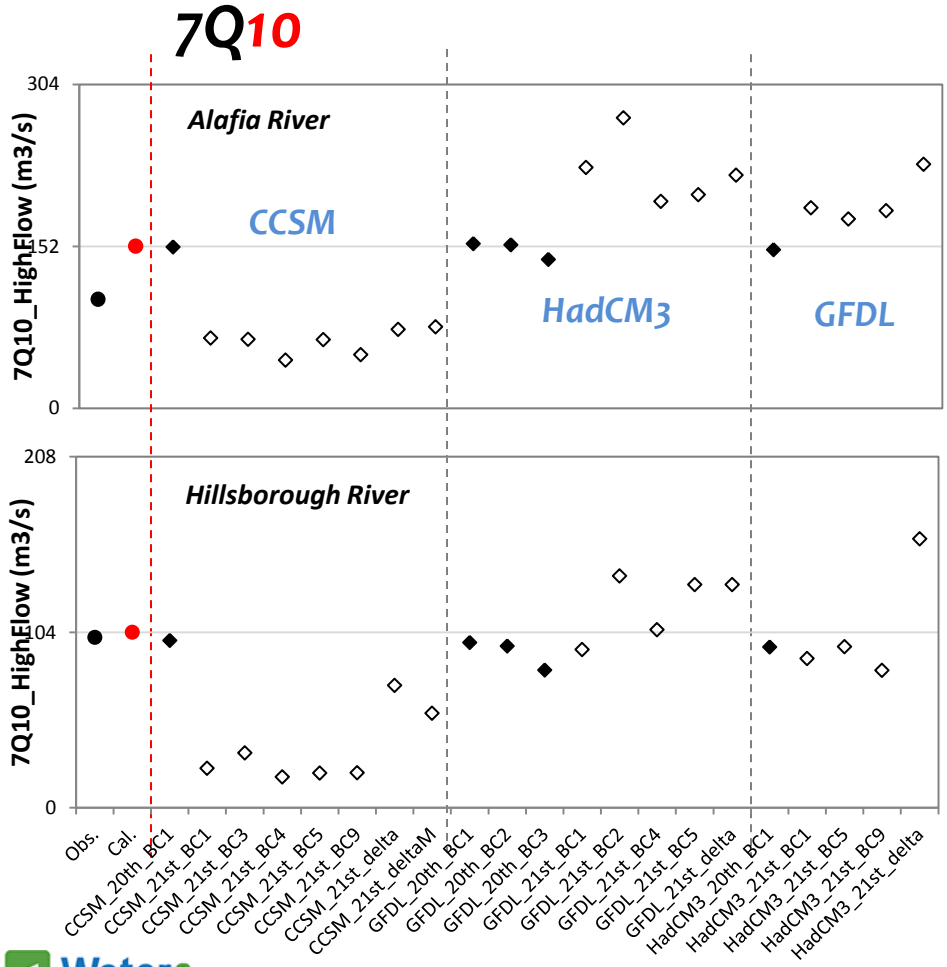
UF Water Institute | University of Florida

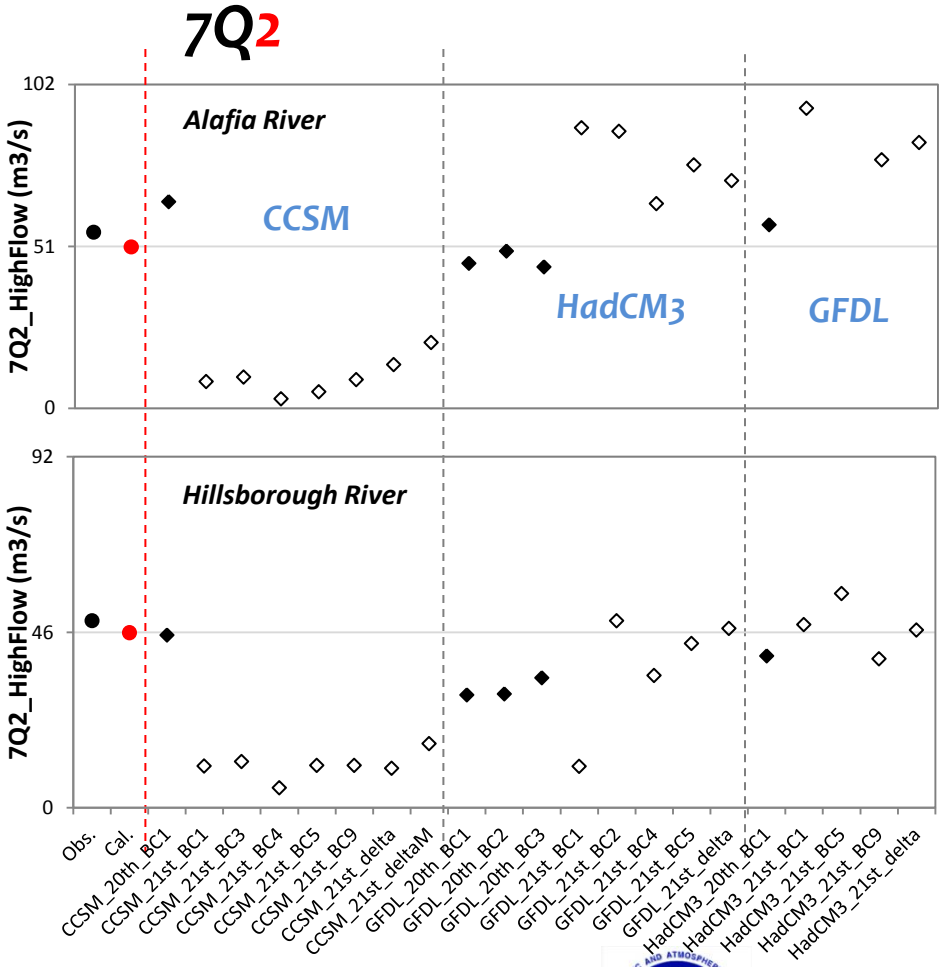
NOAA

Tampa Bay Water

3.3 Design flow estimation

7Q10 and 7Q2 means the average maximum flow for seven consecutive days that has probable recurrence interval of once in ten and two years, respectively.





FLORIDA Water & Climate Alliance

UF Water Institute UNIVERSITY of FLORIDA

NOAA

TAMPA BAY WATER