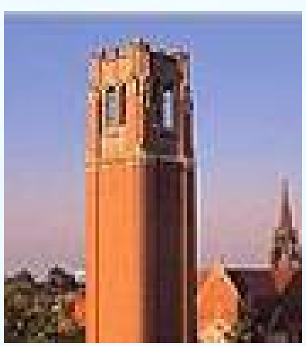
The University of Florida Water Institute



Wendy Graham, Ph. D., Water Institute Direct orCarl Swisher Eminent Scholar

UF | Water Institute
UNIVERSITY *of* FLORIDA

01 Introduction

Florida Water and Climate Alliance

A Stakeholder-Scientist Network

FLORIDA Water & Climate Alliance

Goal: To increase the regional relevance and usability of climate and sea level rise models for the specific needs of water suppliers and resources managers in Florida.

01 Introduction

Tampa Bay Water Project Objectives

- Evaluate the ability of Global Climate Models (GCMs) to reproduce retrospective temperature and rainfall in the Tampa Bay Region

- Evaluate the ability of GCMs to reproduce retrospective hydrologic behavior when used with the calibrated Integrated Northern Tampa Bay (INTB) Model

- Evaluate changes in hydrology resulting from GCM future climate projections

- Quantify the relative uncertainties of changes in future climate and water use scenarios for water supply planning

02 Methods and Materials

8 GCMs (CMIP5, RCP8.5)[1]

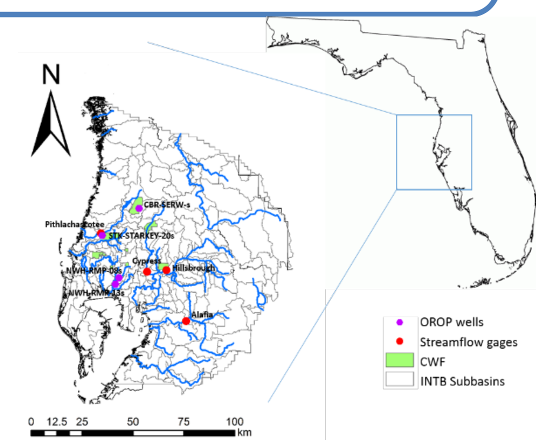
8 Water use scenarios

3 ET_0 estimation Methods[1]
(Hargreaves, Penman-Monteith, Priestly Taylor)

Retrospective period: 1982-2005
Future period 1: 2030-2060
Future period 2: 2070-2100

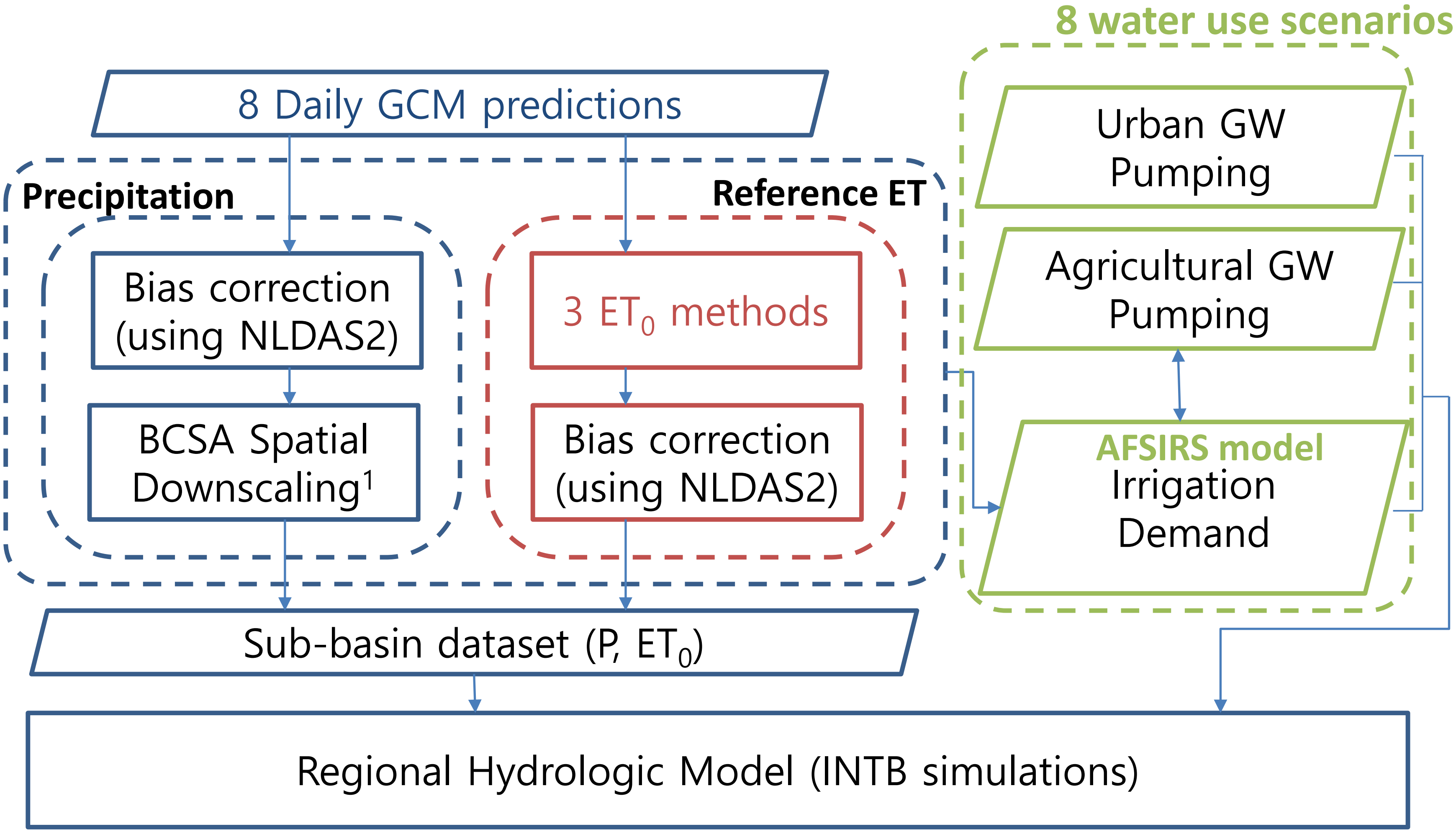
Changes in hydrology, changes in environmental compliance, ability to meet future demand.

- Historic climate data: NLDAS-2 (1/8th degree grid)
- Hydrologic model: Integrated Hydrologic Model (IHM)
- Study region: Integrated Northern Tampa Bay (INTB)



Ref: [1]Chang et al (2016)

02 Methods and Materials



Variance-based GSA and Tukey's HSD test to evaluate the results.

Ref: [1]Hwang & Graham (2013)

Bias Correction Stochastic Analog (BCSA) Downscaling Technique[1]

What we did

Developed a new statistical downscaling method (BCSA) and compared it to existing methods (BCSD, SDBC, BCCA)

Why we did it

Existing statistical downscaling methods did not reproduce spatio-temporal rainfall characteristics in Florida well

What we found…

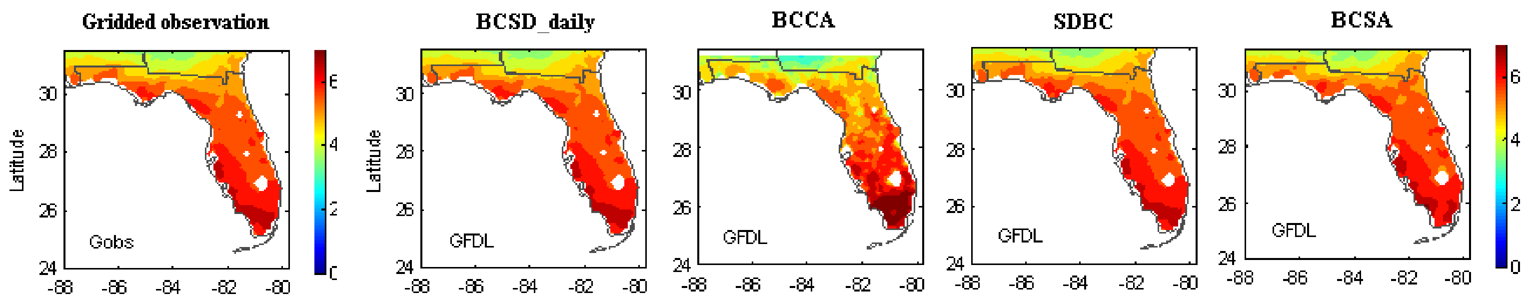
Choice of statistical downscaling method matters in Florida!

Note: Even dynamic downscaling requires bias correction before use in hydrologic models !

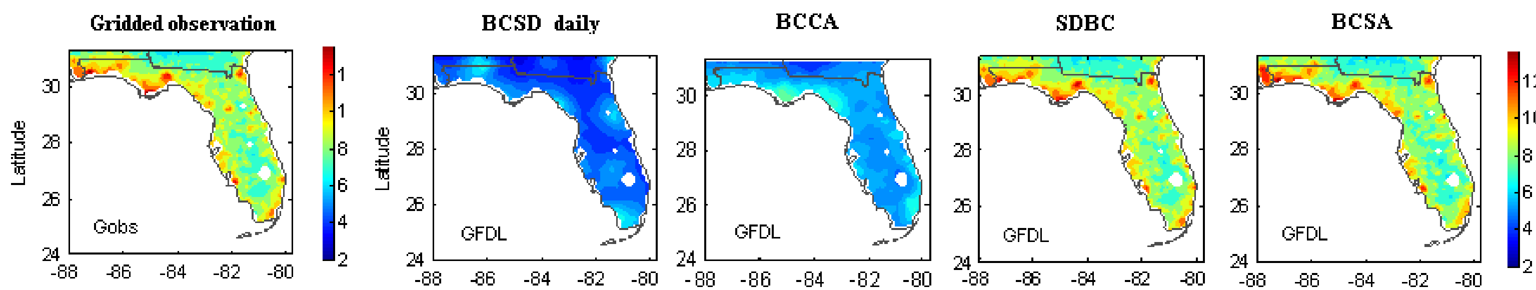
Ref: [1]**Hwang & Graham (2013a)**
[2]**Hwang & Graham (2013b, 2014)**

03 Results: Comparison of Downscaling Methods

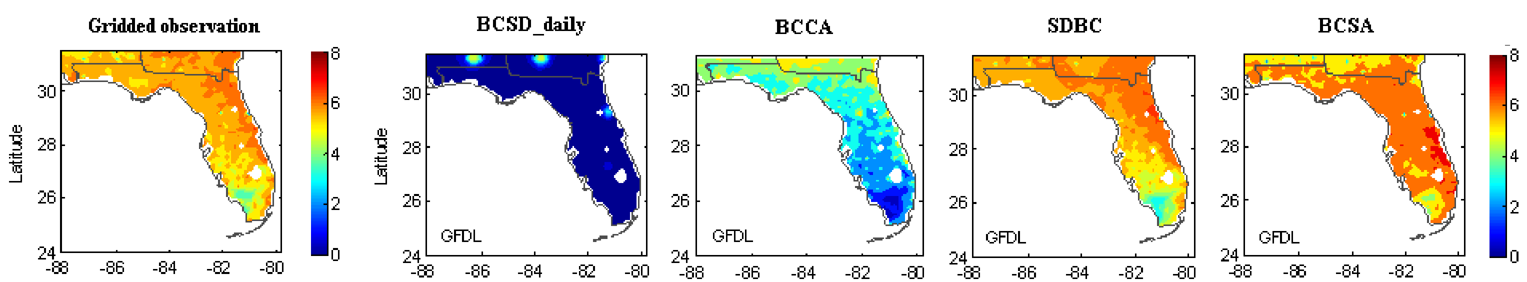
Wet season average daily rainfall



Wet season standard deviation of daily rainfall



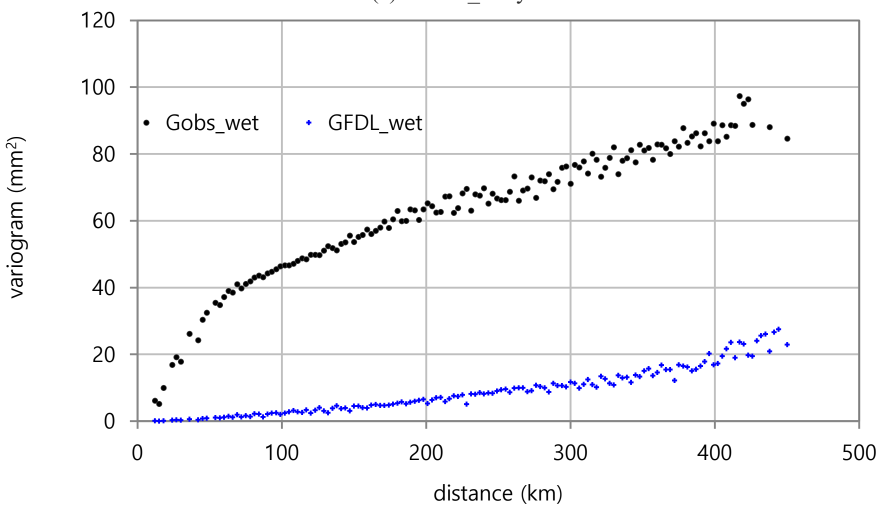
Wet season frequency of wet spells >5 days



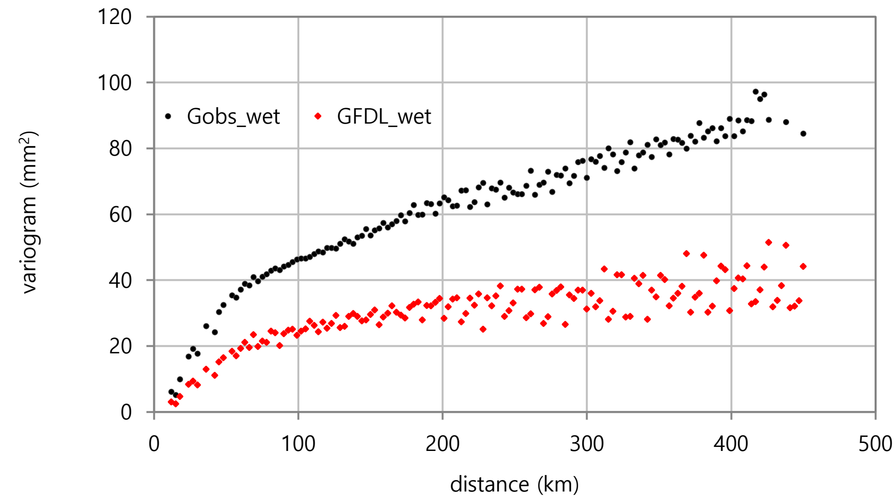
03 Results: Comparison of Downscaling Methods

Wet season spatial structure

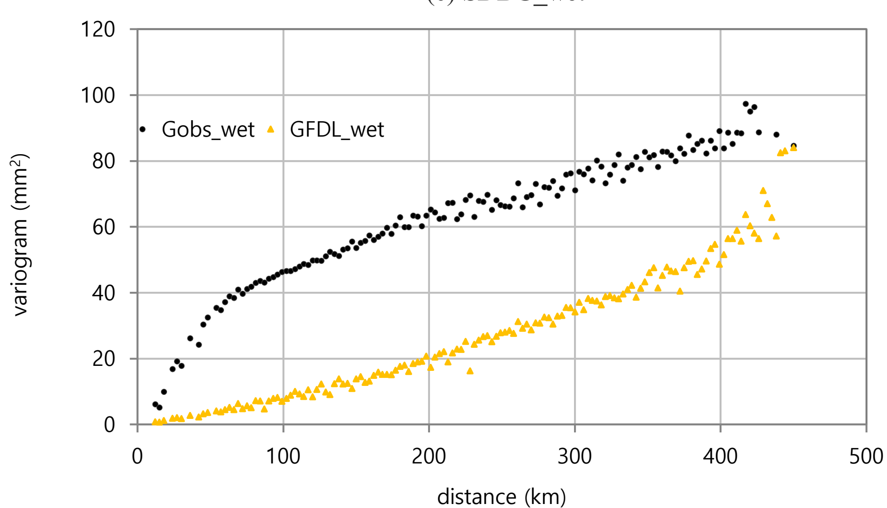
(a) **BCSD**_daily wet



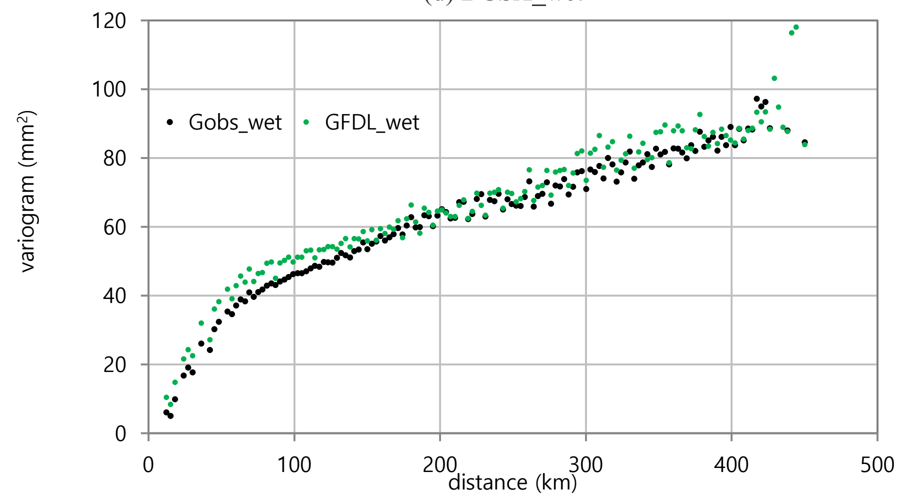
(b) **BCCA**_wet



(c) **SDBC**_wet

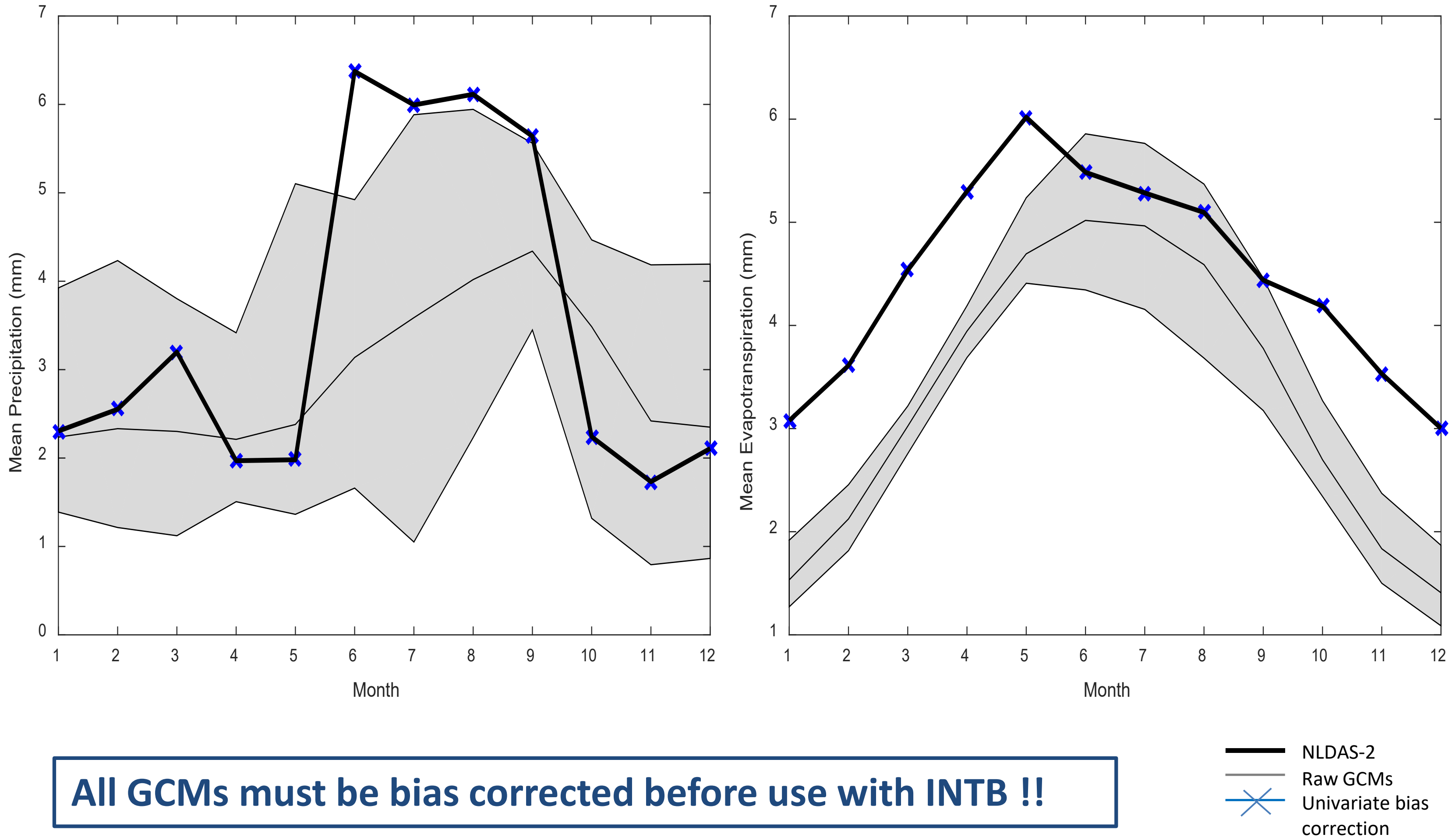


(d) **BCSA**_wet



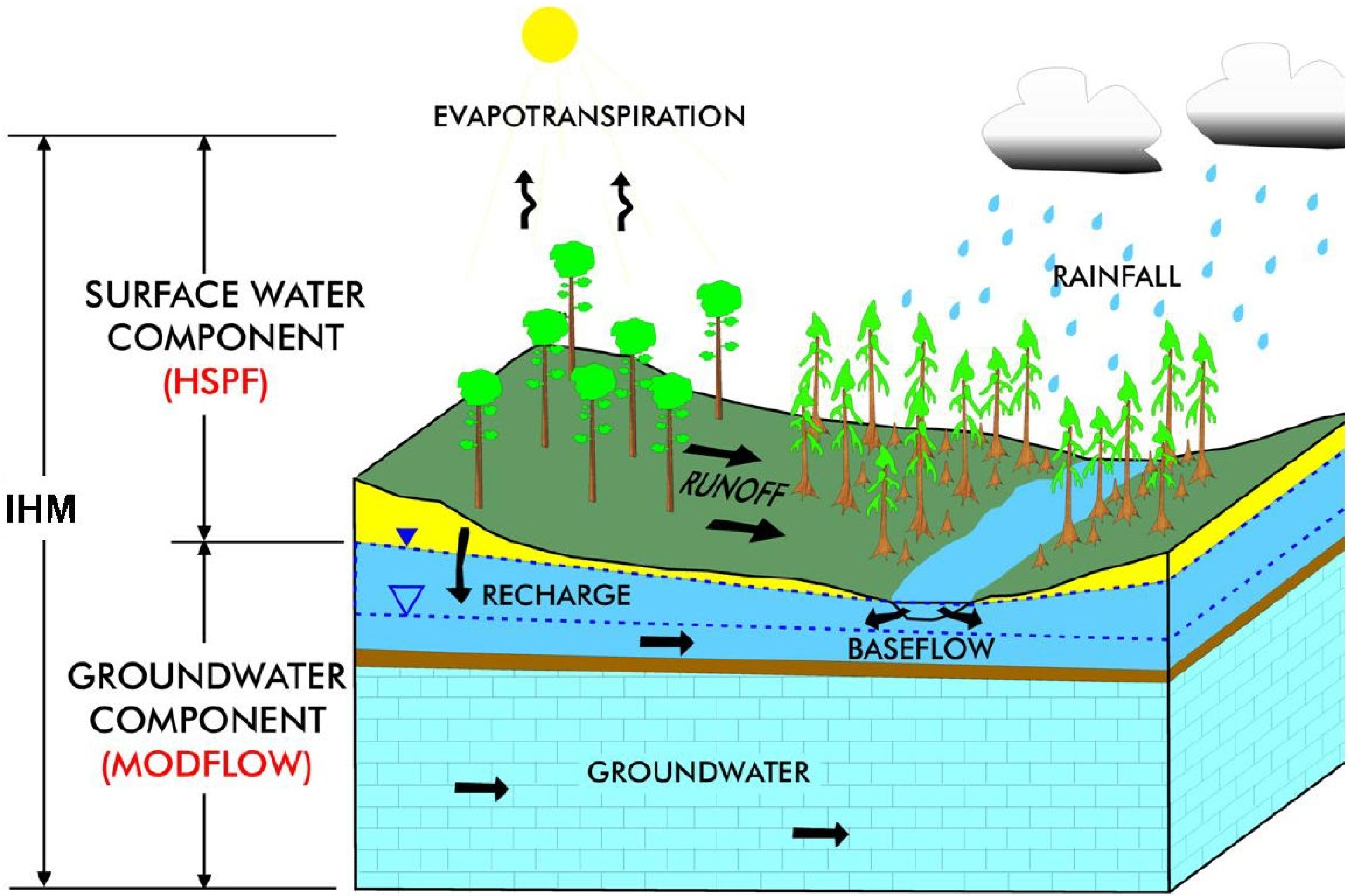
03 Results

Comparison of raw and downscaled, bias-corrected retrospective P and ET_0



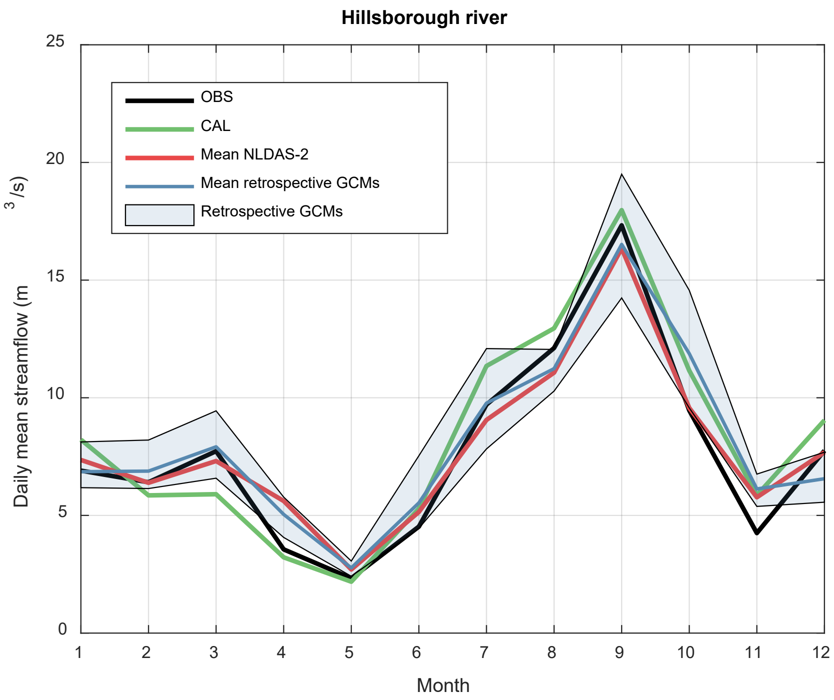
All GCMs must be bias corrected before use with INTB !!

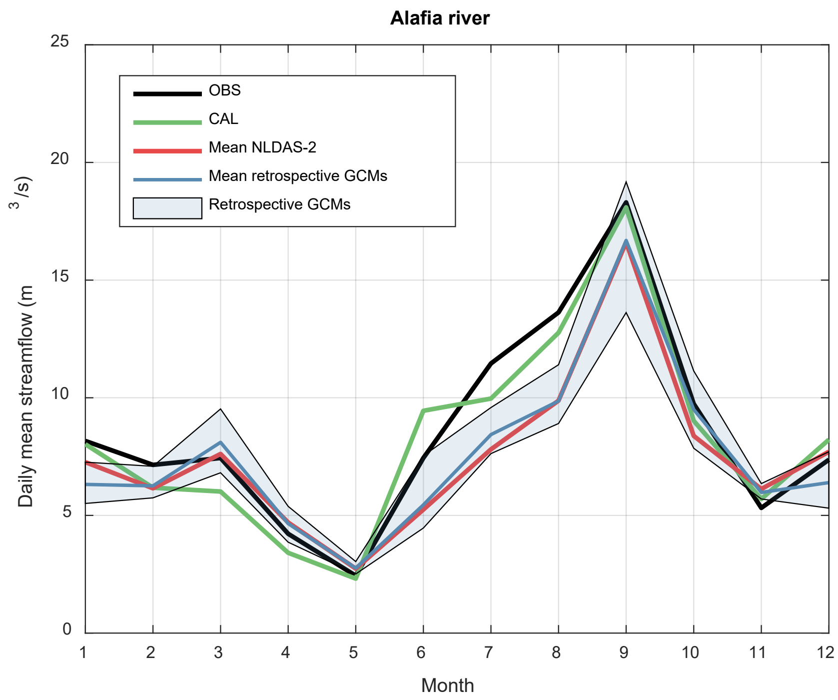
Integrated Hydrologic Model (IHM)



03 Results

Comparison of retrospective monthly streamflow predicitions



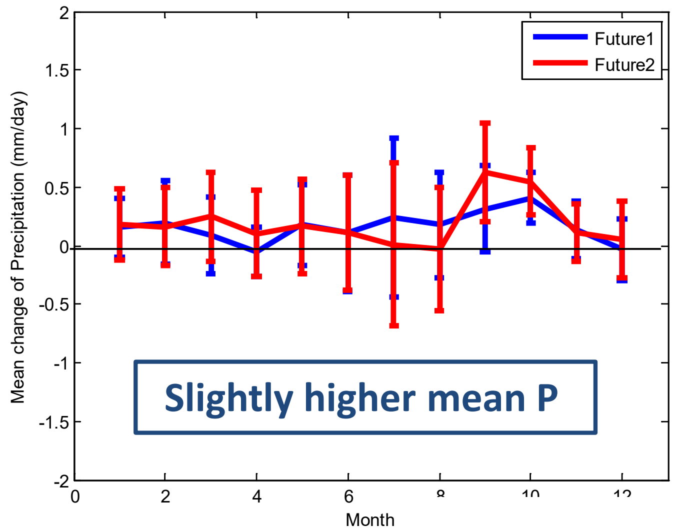


Retrospective streamflow OK after P and ET_0 bias-correction

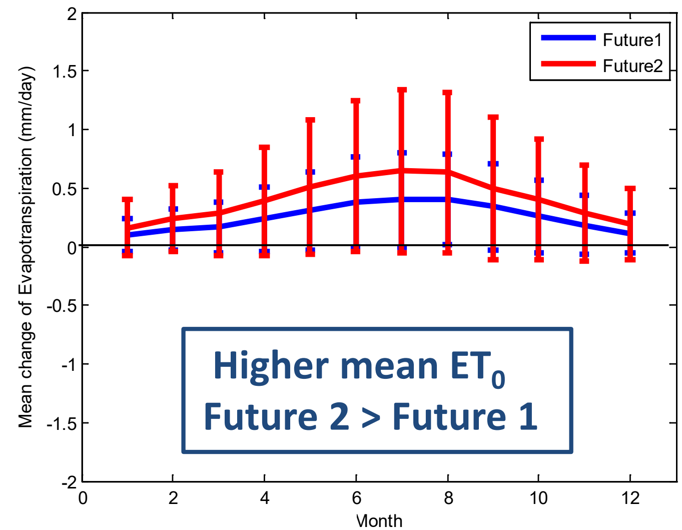
03 Results

Projected future monthly change in P, ET_0 and ($P-ET_0$)

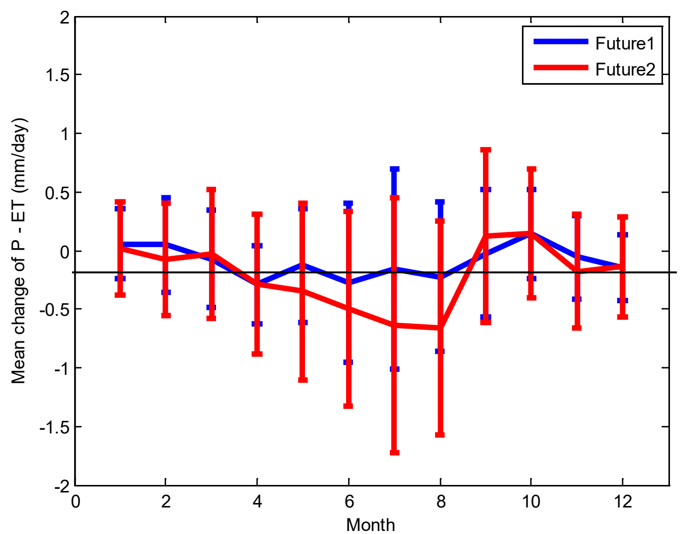
P



ET_0



$P - ET_0$



Mean $P-ET_0$ lower in summer months for Future 2

Large spread in projections depending on GCM and ET Method!!

2045 Water Use Scenarios: Demand Assumptions

- Tampa Bay Water Urban demand projected to be ~280 MGD in 2045 assuming active water conservation.
- Climate-driven agricultural irrigation water demand estimated by the AFSIRS model using GCM future projections
- Land use change not considered. Increases in demand assumed to be the result of intensification on existing lands

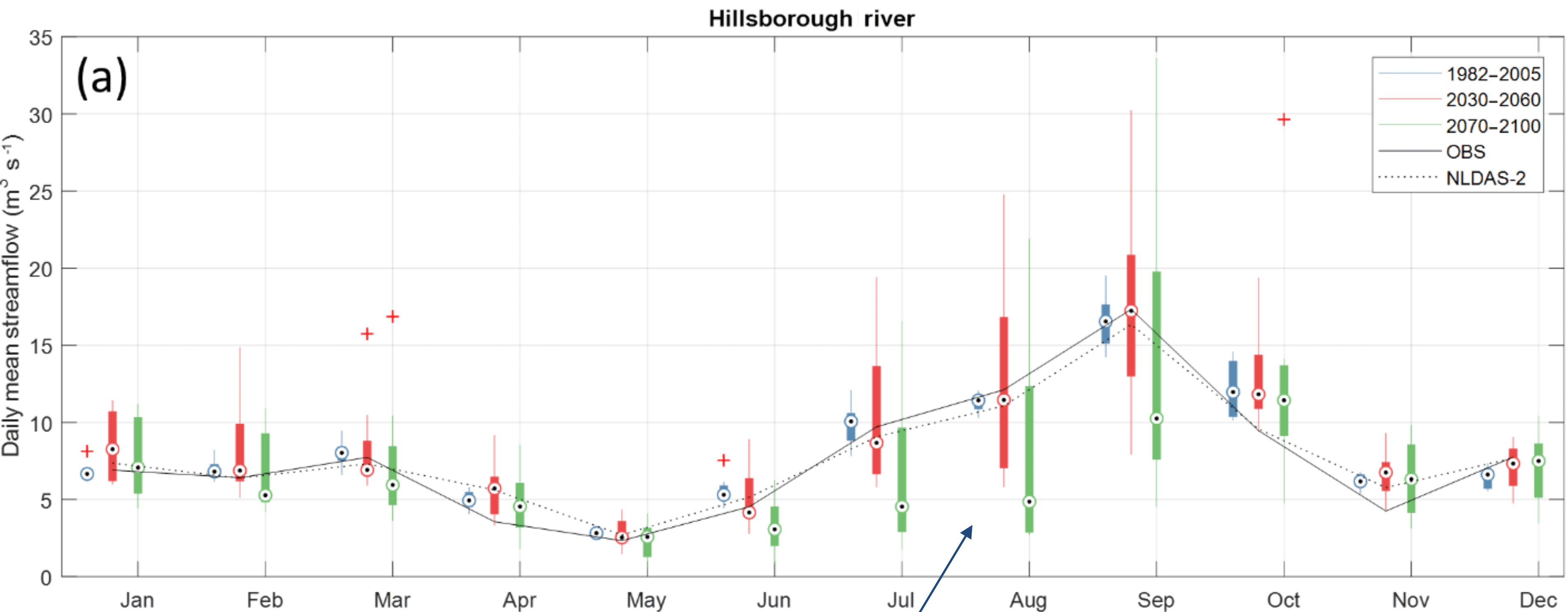
2045 Water Use Scenarios

Scenario	Groundwater Pumping for Retrospective Climate (MGD)			
	Irrigation Demand	Agricultural Pumping[1]	Urban Pumping[2] (CWF)[3]	Total GW Pumping
No groundwater pumping	0	0	0	0
No urban groundwater pumping	163	192	0	192
No agricultural groundwater pumping	0	0	356(90)	356
Agricultural adaptation (25% reduction)[4]	129	152	356(90)	508
Business as Usual	163	192	356(90)	548
Increase agricultural demand (25% increase)[4]	203	239	356(90)	595
Increase CWF groundwater pumping (45%)	163	192	396(130)	588
Increase all urban groundwater pumping (45%)	163	192	514(130)	706

- [1]Agricultural = agricultural & recreational
- [2]Urban = public water supply & industrial
- [3]CWFs: Consolidated wellfields
- [4]redcution/increase over climate driven demand

03 Results

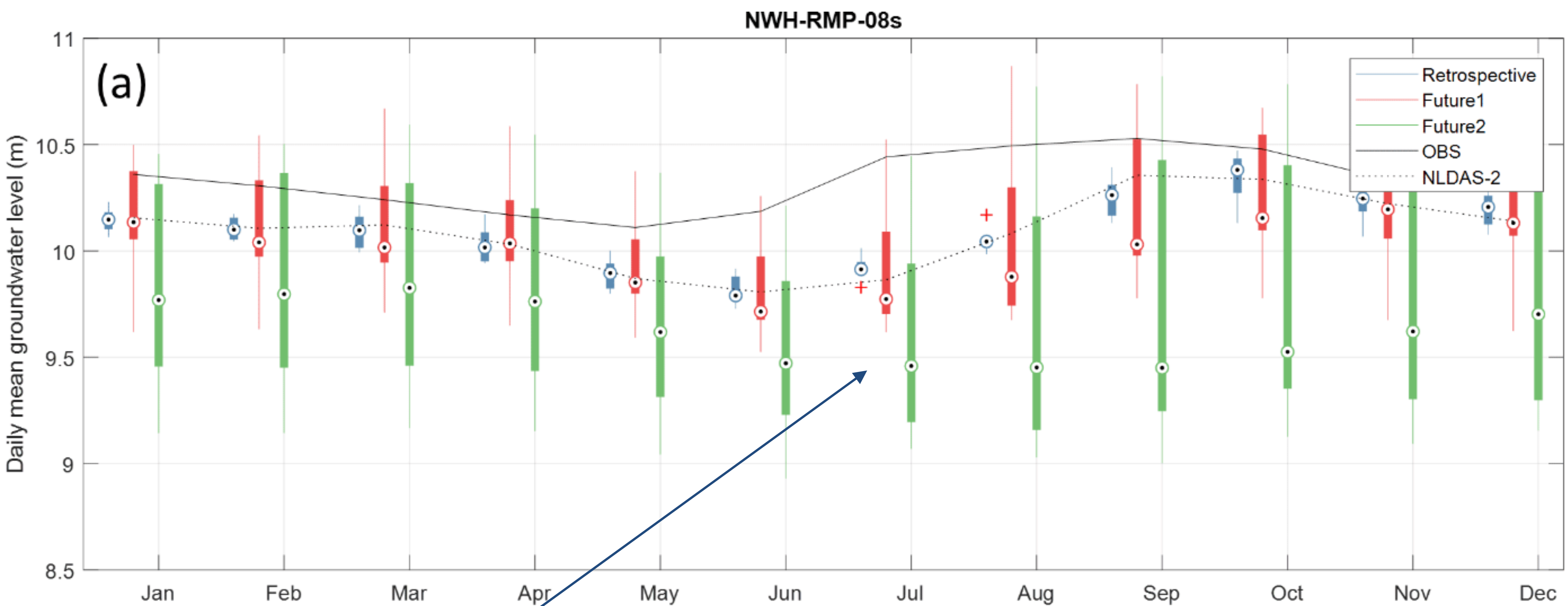
Retrospective versus future mean daily streamflow (Business as usual scenario, Hargreaves ET)



Lower mean streamflow in summer months. Future 2 < Future 1. Large spread in future projections!

03 Results

Retrospective versus future mean daily groundwater level (Business as usual scenario, Hargreaves ET)



Lower mean groundwater levels. Future 2 < Future 1. Large spread in future projections!

Global Sensitivity Analysis

The first order sensitivity index of change in streamflow

River gage	Season	Period	GCM	ET	Scenario
Hillsborough	Wet season	Fut1	0.944	0.002	0.016
		Fut2	0.930	0.041	0.006
	Dry season	Fut1	0.948	0.012	0.029
		Fut2	0.961	0.001	0.018

GCM is dominant cause of spread in projections

ET and Water Use Scenario low

Global Sensitivity Analysis

The first order sensitivity index of change in groundwater level

GCM and water use scenario are both significant sources of spread

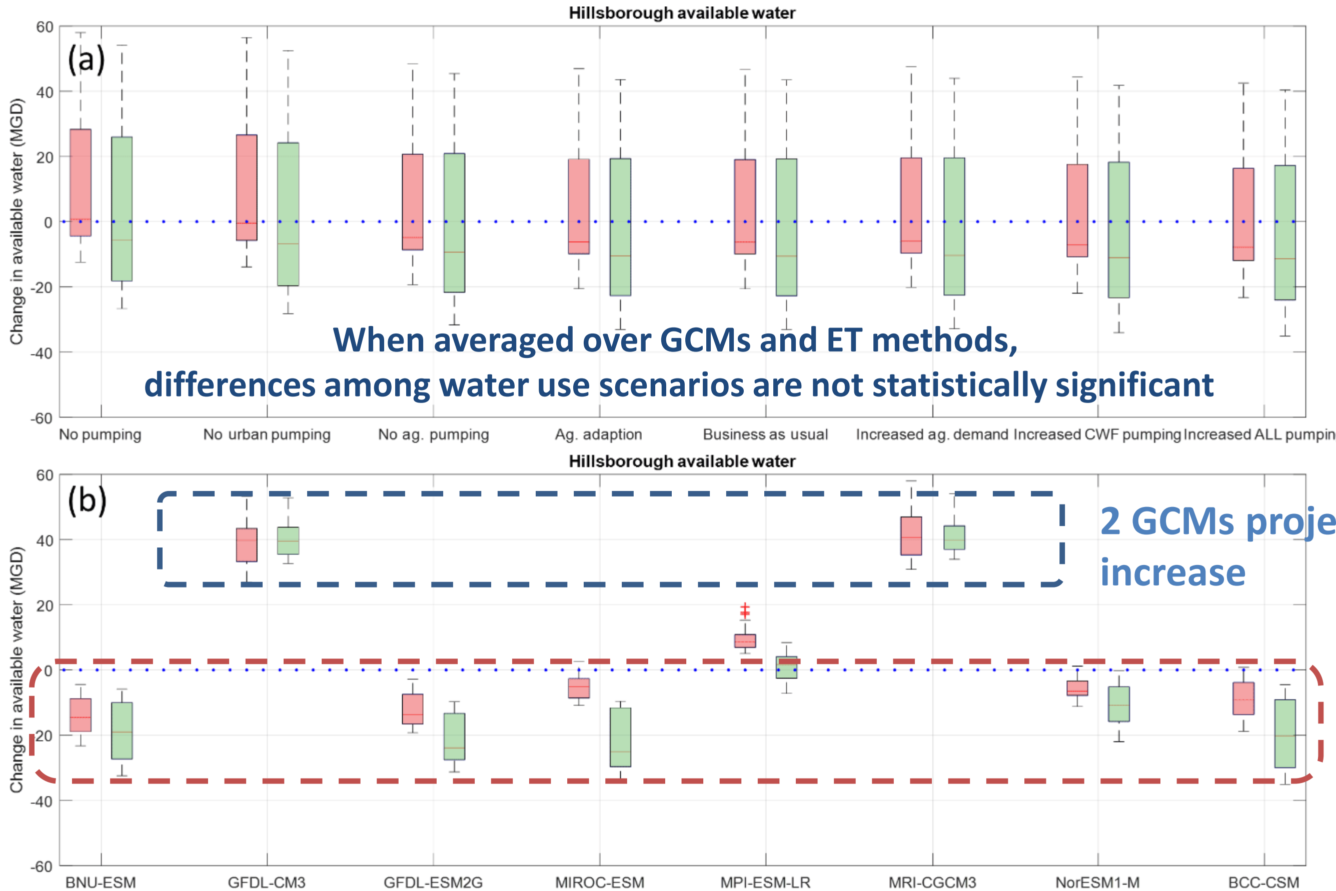
OROP well	Season	Period	GCM	MET	Scenario
NWH-RMP-08s	Wet season	Fut1	0.442	0.005	0.501
		Fut2	0.576	0.004	0.278
	Dry season	Fut1	0.475	0.007	0.435
		Fut2	0.550	0.002	0.288

03 Results

Change in available water from the Hillsborough River

By water use scenario

By GCM



2 GCMs projected increase

5 GCMs projected decrease

When averaged over water use scenarios and ET method,
Differences among GCMs are statistically significant

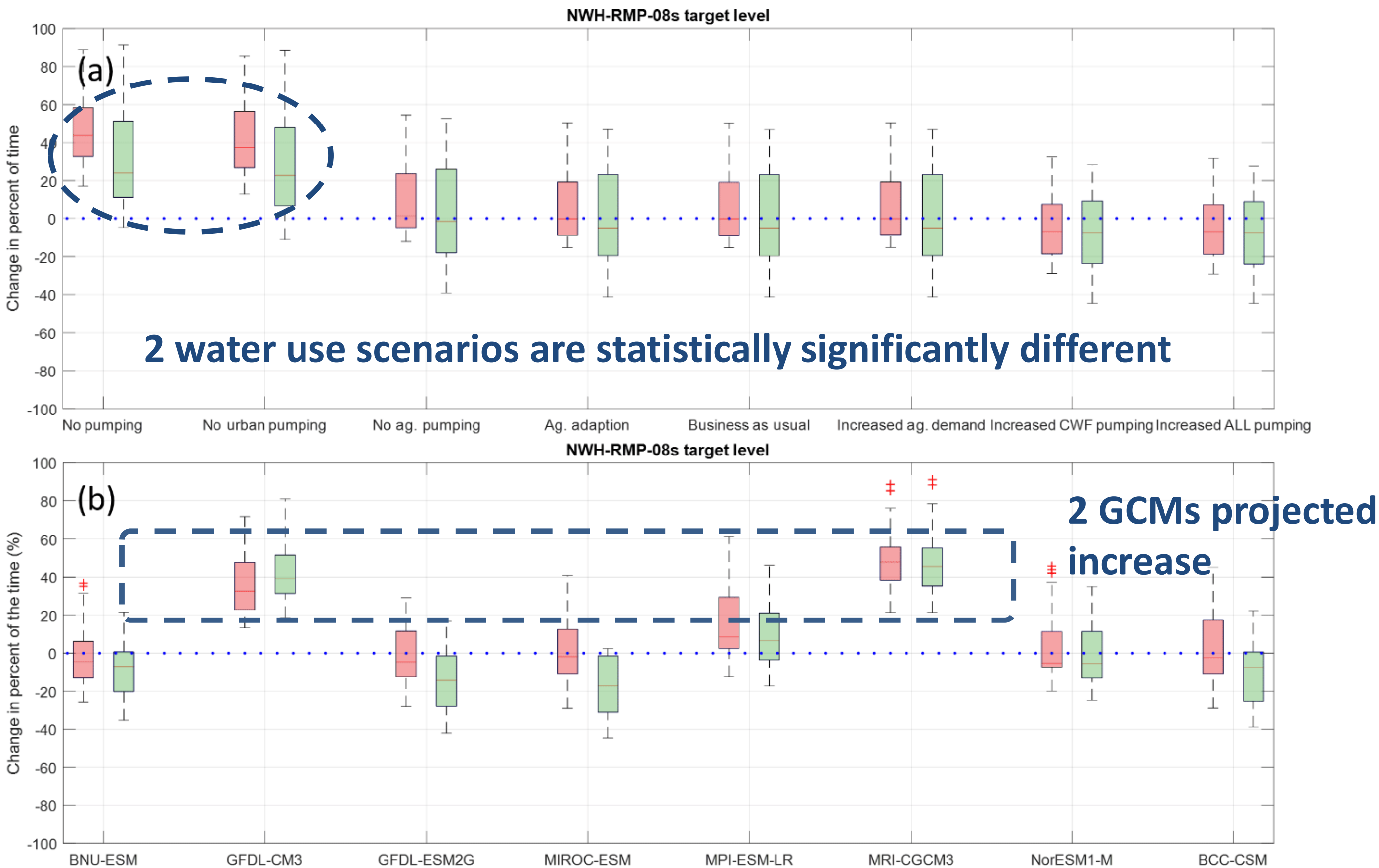
02 Results

Change in percent of the time that GW is above target level

By water use scenario

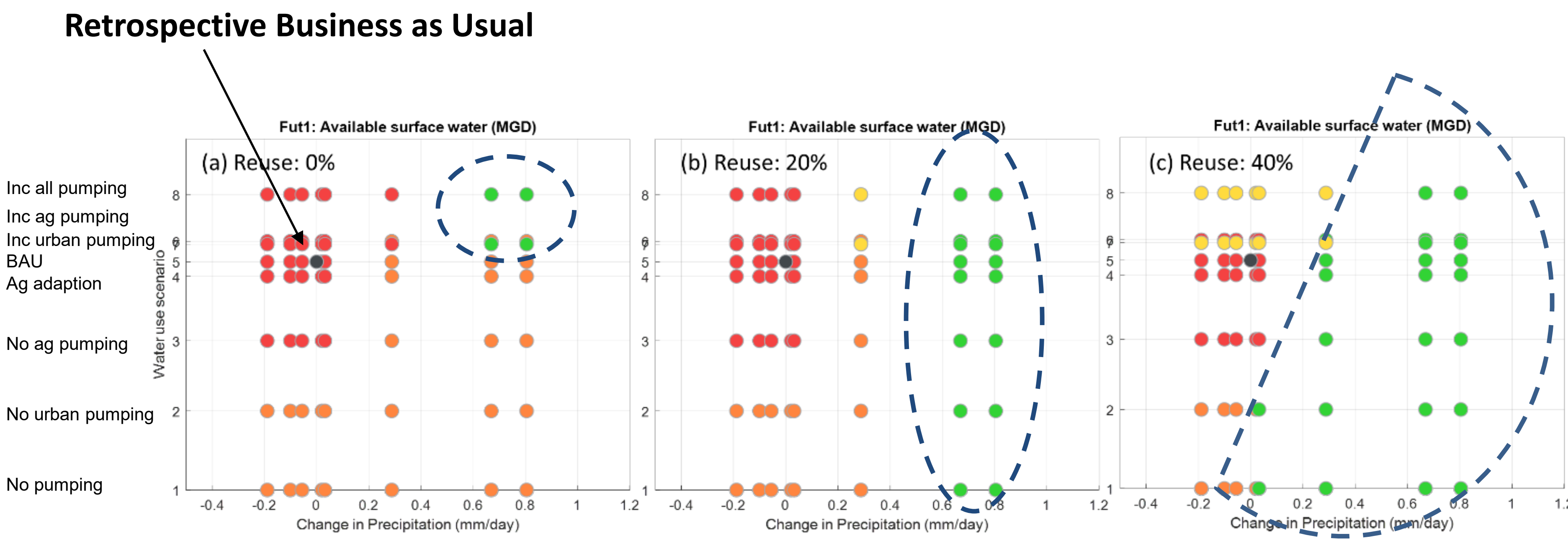
Reduction in municipal pumping leads to increase in time GW is above target at this well

By GCM



Differences among GCMs are statistically significant

Scenario Discovery Analysis[1]: Ability to meet Tampa Bay Water projected 2045 demand and meet environmental regulations



- Meets 2045 demand and maintains compliance with groundwater regulations
- Meets 2045 demand but does not maintains compliance with regulations
- Does not meet 2045 demand but maintains compliance with regulations
- Does not meet 2045 demand or maintains compliance regulations

Refs[1]: Tariq et al (2017)
Chang et al (2018)

Take home messages

- Downscaling technique matters! Even dynamically downscaled GCMs must be bias corrected.
- Projected changes in streamflow and groundwater level vary depending on choice of GCM, ET method, water use scenario and RCP scenario
- The uncertainty attributed to GCMs was the dominant factor influencing different future streamflow projections.
- The uncertainty attributed to GCM and water use scenario both contributed to significant differences in future groundwater level projections.
- For the three ET methods shown here, uncertainty is relatively small.
- Climate models projected significantly different changes in streamflow and groundwater. 5 to 6 GCMs among 8 projected decreases in water availability.
- Even with active conservation and dramatic increases in use of reclaimed water current regulations on water withdrawals may have to adapt to future climate.

Evapotranspiration Method Selection

- What we did
  - Evaluated uncertainty in P, T, and ET_0 projections using Global Sensitivity Analysis and Monte Carlo Filtering
- Why we did it
  - To develop an appropriate ensemble of GCMs, ET methods and RCP trajectories for evaluating future climate change
- What we found
  - Choice of ET method matters!
  - Evaluate impacts of future projections over an ensemble of GCMs and a variety of ET methods and RCP trajectories

Ref: Chang et al (2016)

2070-2100 Change in Annual P-ET_0 by ET method (averaged over GCMs and RCPs)

Penman-Monteith

Hargreaves

Blaney-Criddle

Irmak- Rn

Irmak- Rs

Hamon

Dalton

Kharrufa (PET)

Meyer

Priestly Taylor (PET)