

Evaluation of dynamically and statistically downscaled climate model results

for use with Tampa Bay Water's Integrated Hydrologic Modeling Tool



Wendy Graham
SyeWoon Hwang

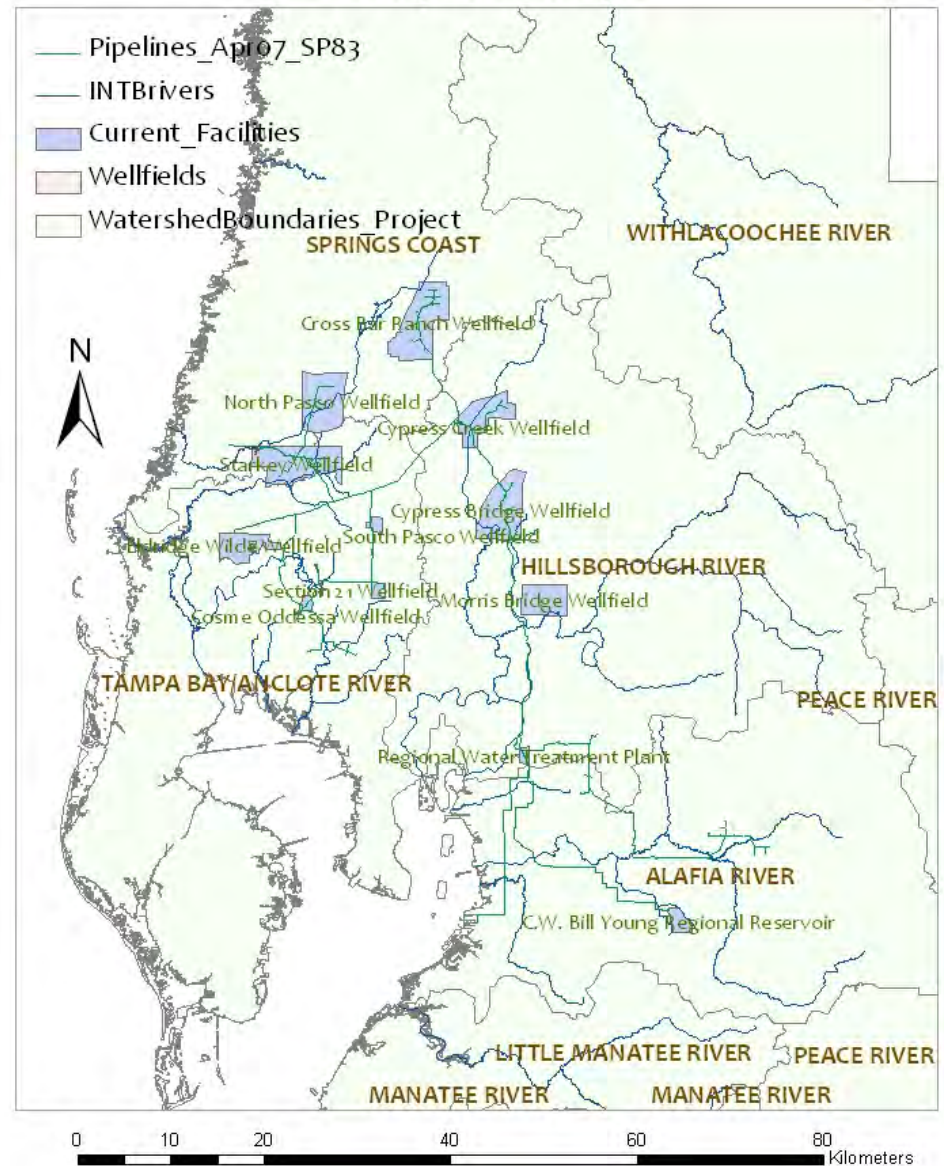


Water Institute, University of Florida

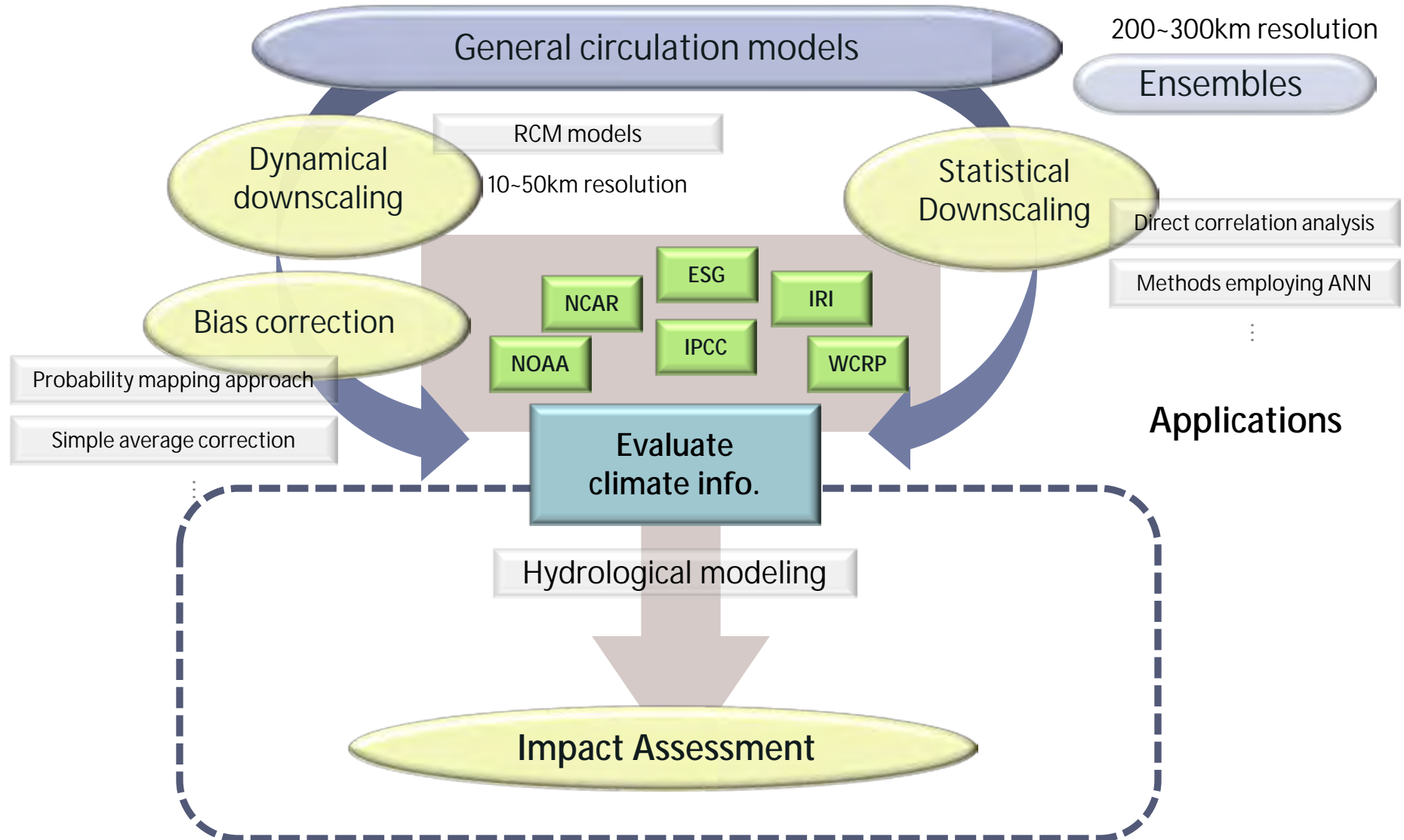
Tampa Bay Water

.... In this project we are using dynamically and statistically downscaled climate model output to drive hydrologic models to explore potential impacts of climate variability and climate change on water availability and water allocation decisions

Study area map



BIG PICTURE



Available downscaled climate modeling results for the study area

- } **Bias corrected MM5 (1986-2008)**
 - } Dynamically downscaled by UF using NCEP-NCAR reanalysis as Boundary Conditions
 - } 3 spatial resolutions (3km, 9km, and 27km) over the Tampa Bay region
 - } Bias corrected using 53 long-term point observations in the region

- } **COAPS Land-Atmosphere Regional Reanalysis: NCEP-Scripps RSM (1979-2001)**
 - } Dynamically downscaled by FSU using NCEP-DOE II ECMWF/ERA-40 reanalyses as Boundary Conditions
 - } 10km spatial resolution over southeastern US (Domain: 90W-76W, 24N-36N)
 - } No additional bias correction
 - } <ftp://coaps.fsu.edu/pub/CLARReS10/>

- } **BCSD WCRP CMIP3 (1950-1999 & 2000-2099) ...results to be discussed today**
 - } 16GCM predictions: bias corrected and statistically downscaled
 - } Bias corrected data available at monthly timescale, 12km resolution
 - } Raw data available at daily timescale, 12 km resolution
 - } Available for download in NetCDF data format or ASCII text format

- } **NARCCAP (1971-2000 & 2041-2070)**
 - } 4GCM*6RCM combinations
 - } Daily time scale, 50km resolution
 - } Available for download in NetCDF data format (as completed)

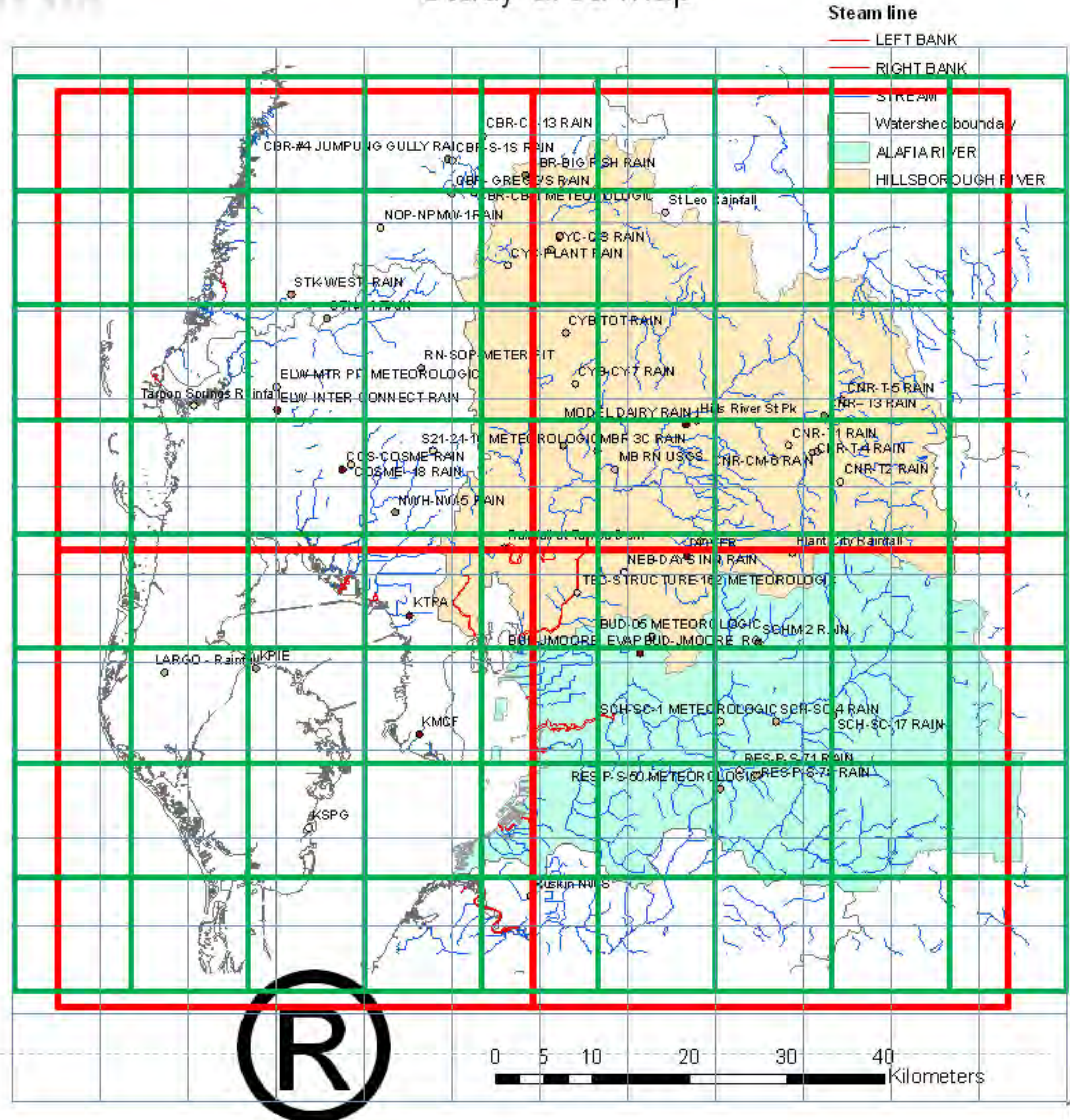
SPATIAL RESOLUTION

MM5
downscaled results
(9km × 9km)

BCSD CMIP3 data
(12km × 12km)

NNARCCAP data
(50km × 50km)

Study area map



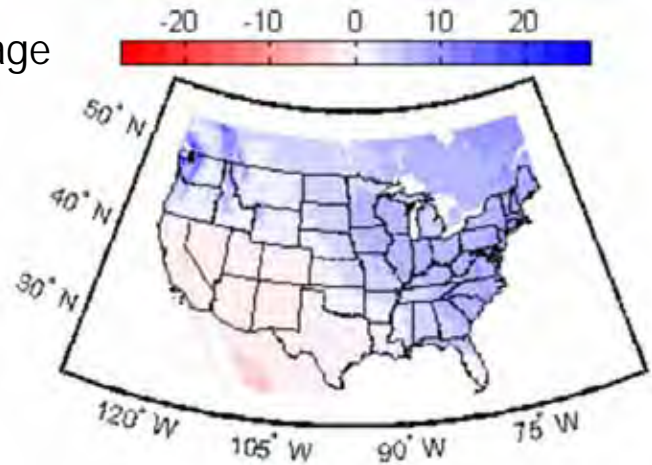
IHM modeling Plans

		Precipitation	Temperature	Production	Diversion	Irrigation	Status
Task 1	1	Obs. (89'-97')	Obs.	Obs.	Obs.	Obs.	complete
	2	MM5 (89'-97')	MM5	Obs.	Obs.	Obs.	complete
Task 2	3	BCSD_GCM (89'-97')	BCSD_GCM	Obs.	Obs.	Obs.	1 of 16 GCMs complete
	4	BCSD_GCM (future)	BCSD_GCM	Scenario	Scenario	Scenario	Near term
Task 3	5	NARCCAP (89'-97')	NARCCAP	Obs.	Obs.	Obs.	future
	6	NARCCAP (future)	NARCCAP	Scenario	Scenario	Scenario	future

WCRP CMIP3

Spatial Coverage

- } 16 GCMs (1950~1999 & 2000~2099)
- } 3 scenarios for future greenhouse gas emissions
- } Bias correction
 - } probability mapping approach



Bias Corrected and Downscaled WCRP CMIP3 Climate Projections

This site has been optimized for Internet Explorer (IE) 6*, IE 7*, and Firefox 2*.
Requires JavaScript to be enabled.

Click on the top tabs below for information on how this archive relates the WCRP CMIP3 effort, the scope of archive contents, dataset attributes (e.g., variables, spatial/temporal coverage and resolution), and methodology used to correct WCRP CMIP3 projections into bias-corrected and spatially downscaled translations.

Background | **Scope** | **Attributes** | **Methodology** | **References**

Climate modeling groups have produced hundreds of simulations of past and future climates for the [Intergovernmental Panel on Climate Change \(IPCC\) Fourth Assessment Report \(AR4\)](#). The WCRP Working Group on Coupled Modelling helped to coordinate these activities through the CMIP3 effort (see Meehl et al. 2007) and worked to co-locate these simulations within a [single archive](#), hosted by the [Lawrence Livermore National Laboratory \(LLNL\) Program for Climate Model Diagnosis and Intercomparison \(PCMDI\)](#). The conversion of all simulation results to a common data format has made probabilistic, multi-model projections and impacts assessments practical.

One issue not solved by the AR4 archive development is that the spatial scale of climate model output is too coarse for most impacts studies and decision-support purposes. Multiple downscaling approaches exist for deriving regional climate from coarse resolution model output (Giongi et al. 2001, Wilby and Wigley 1997). One method of statistically downscaling spatially continuous fields, developed for hydrologic impact studies (Wood et al. 2004), is computationally efficient enough to be easily applied to ensembles of projections (e.g., Maurer 2007), and has compared favorably to other downscaling techniques. Downscaled data developed by this method have been used in the study of potential climate change impacts on various resource systems, including watershed hydrology, reservoir systems, wine grape cultivation, habitat migration, and air quality.

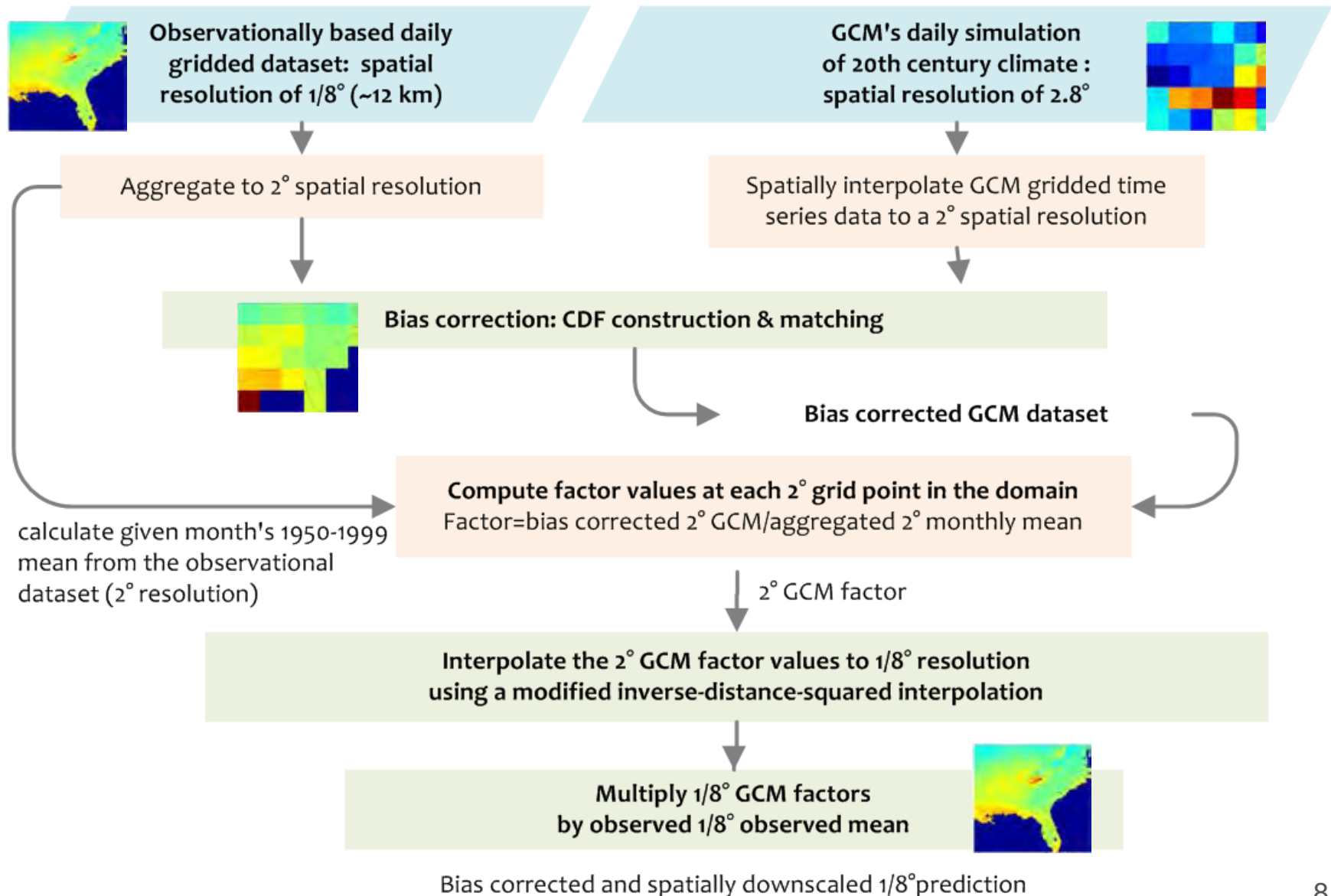
Motivated by a common interest to establish data access for climate change impacts analysts, the U.S. Department of Interior's Bureau of Reclamation (Research and Development Office) and LLNL, through support from the U.S. Department of Energy's National Energy Technology Laboratory and the U.S. Army Corps of Engineers Institute for Water Resources, have teamed with Reclamation's Technical Service Center, Santa Clara University's Civil Engineering Department, Climate Central, and The Institute for Research on Climate Change and its Societal Impacts to develop this public-access archive. Archive content and services are hosted by LLNL Green Data Class. Downscaling was performed using the technique described in (Wood et al. 2004, Maurer 2007) and summarized on the "Methodology" tab here. Users are offered "Standard" and "Custom" data-retrieval options, along with retrieval tutorials and data analysis tools. The "Custom" data-retrieval option permits the user to select subsets of projection data corresponding to particular climate models, emissions pathways, time periods, projected variables, and/or geographical areas.

WCRP CMIP3 archive | Last modified: March 21, 2010
Privacy and Legal Notice | Comments/Questions

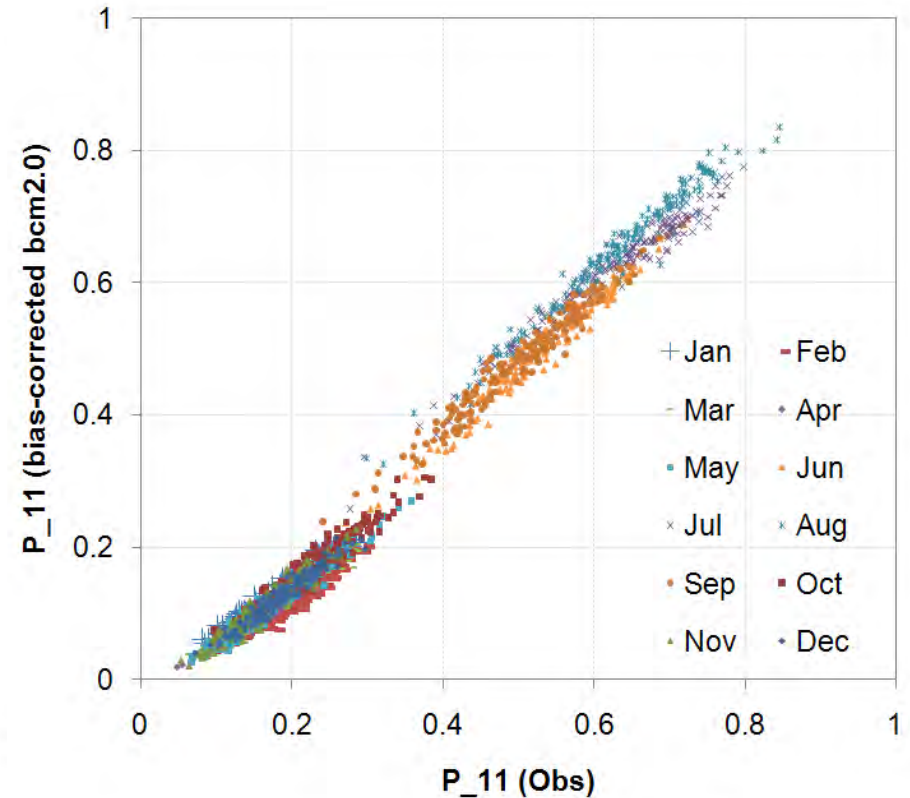
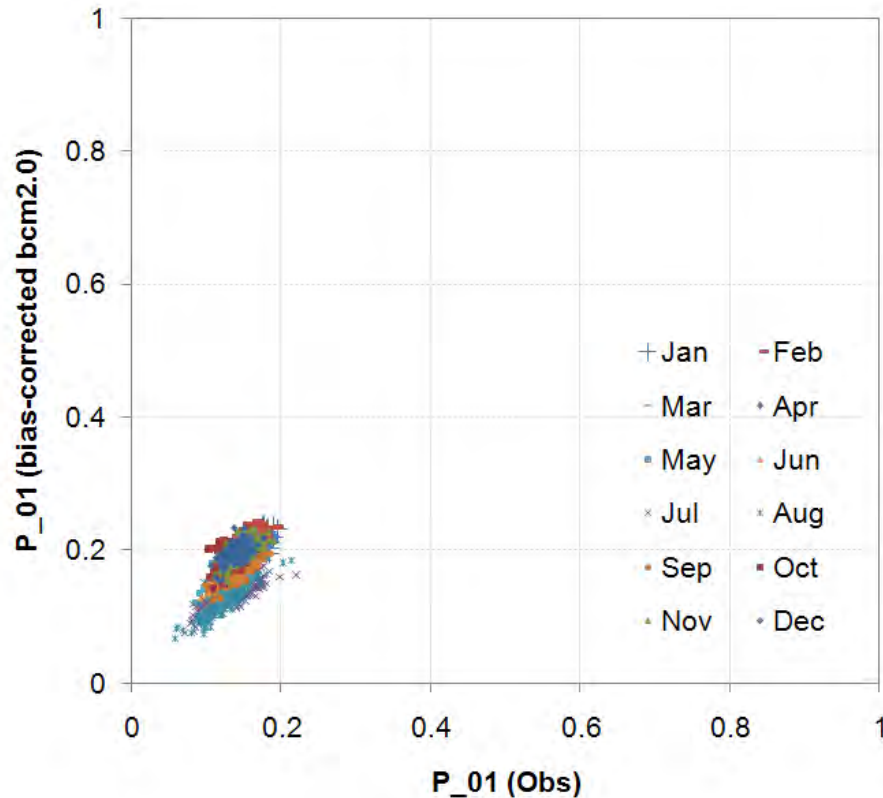
.. Wood et al. (2004)

- } Statistical downscaling
 - } 1/8° grid = 12km resolution
- .. Maurer, E.P. (2002).

BCSD CMIP3 (Daily disaggregation method)



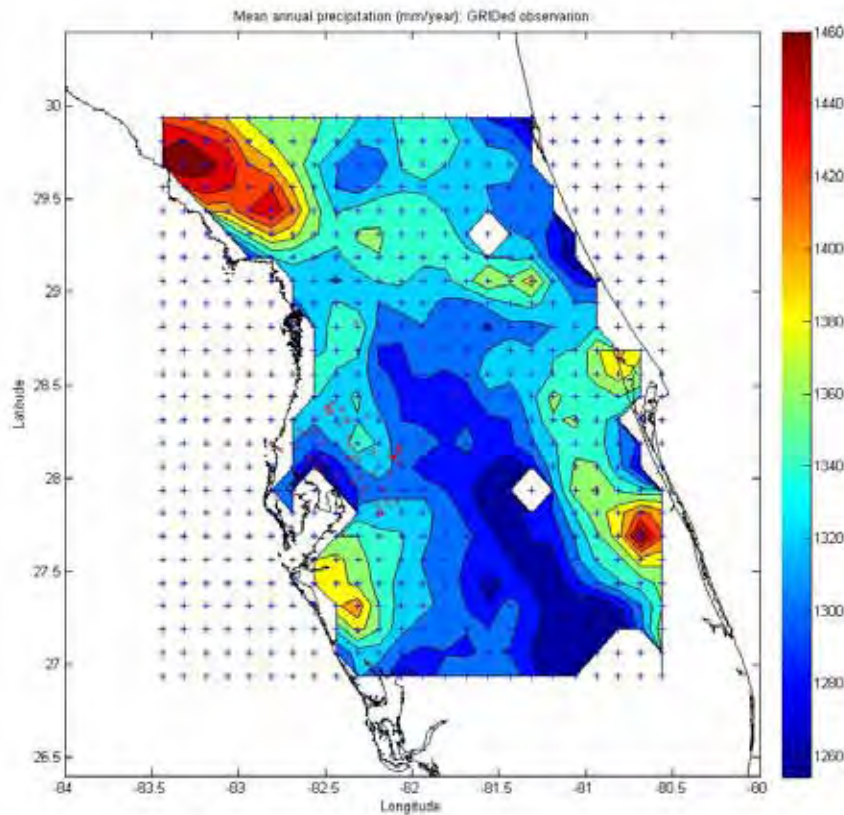
BCSD CMIP3 BCM2.0 vs Observed Transition Probabilities



Mean Annual Precipitation (1961-1999)

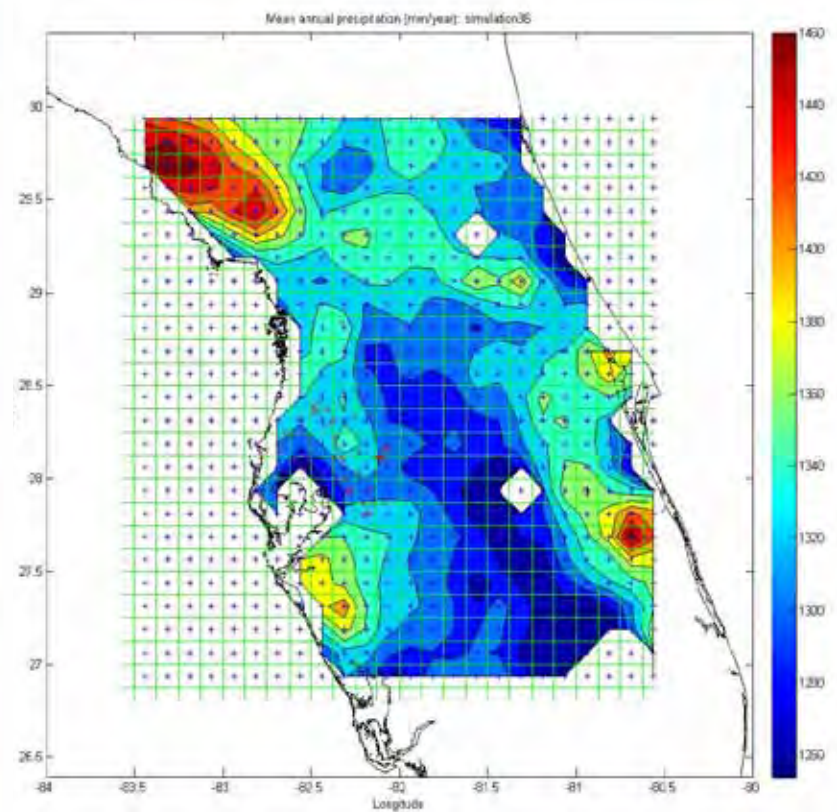
Gridded observation

1260~1460 mm



BCSD CMIP3 BCM2.0

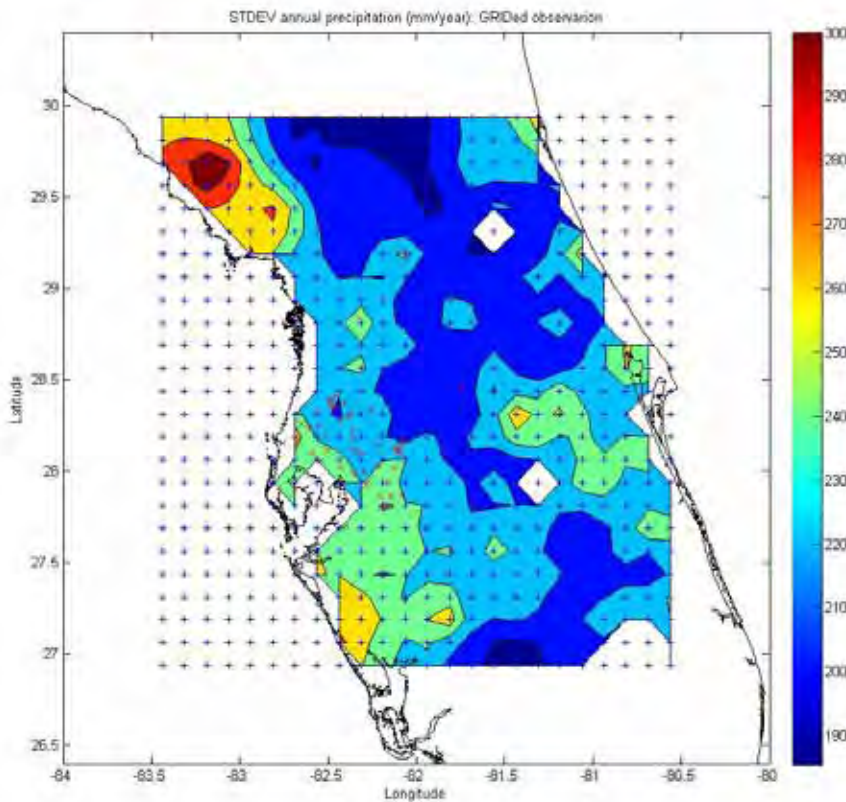
1260~1460 mm



Std Dev of Annual Precipitation (1961-1999)

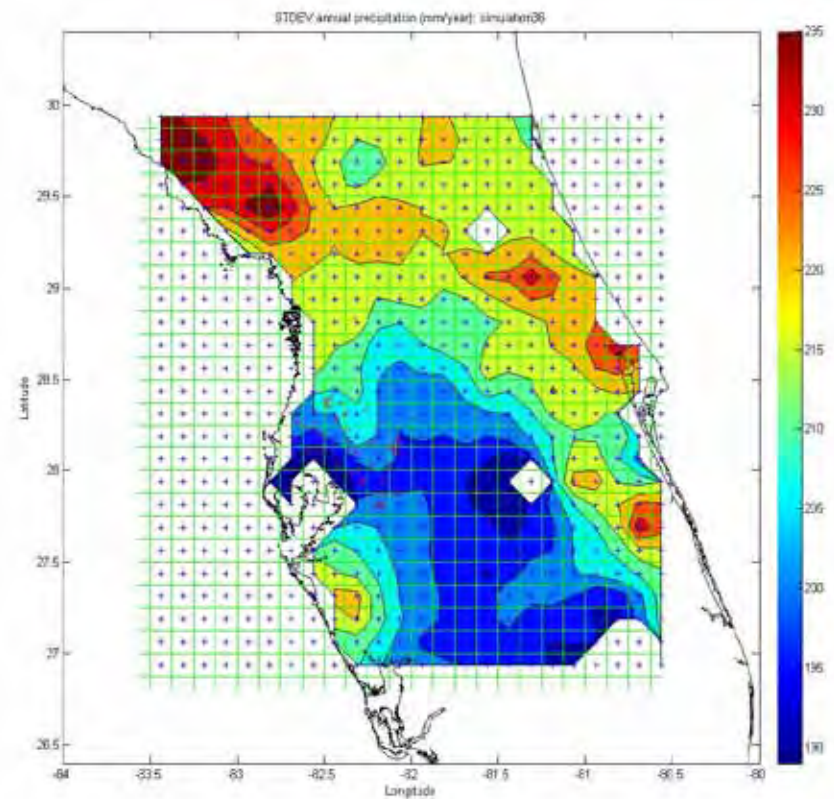
Gridded observation

190~300 mm

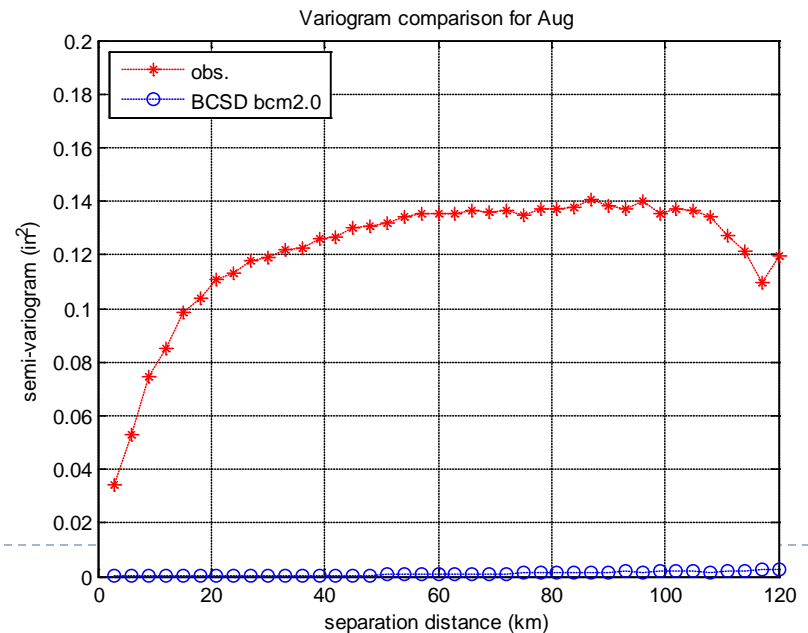
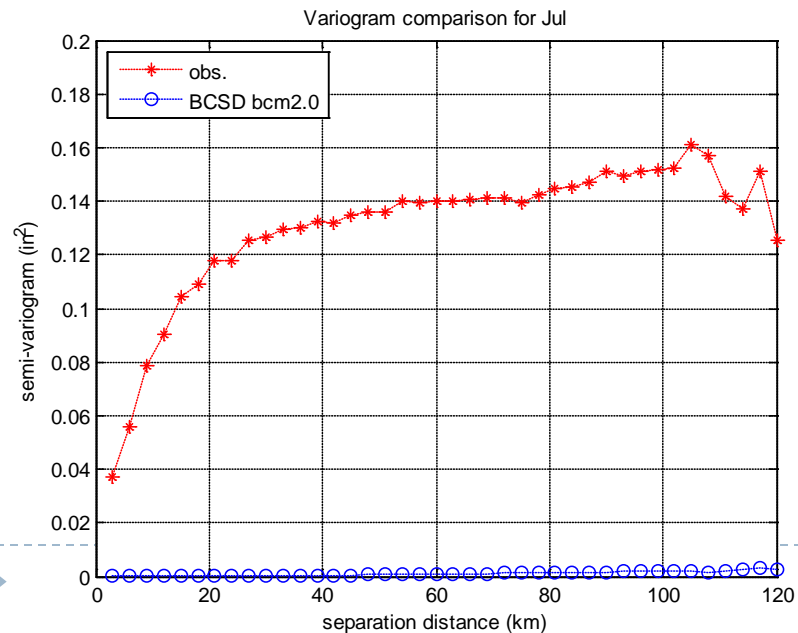
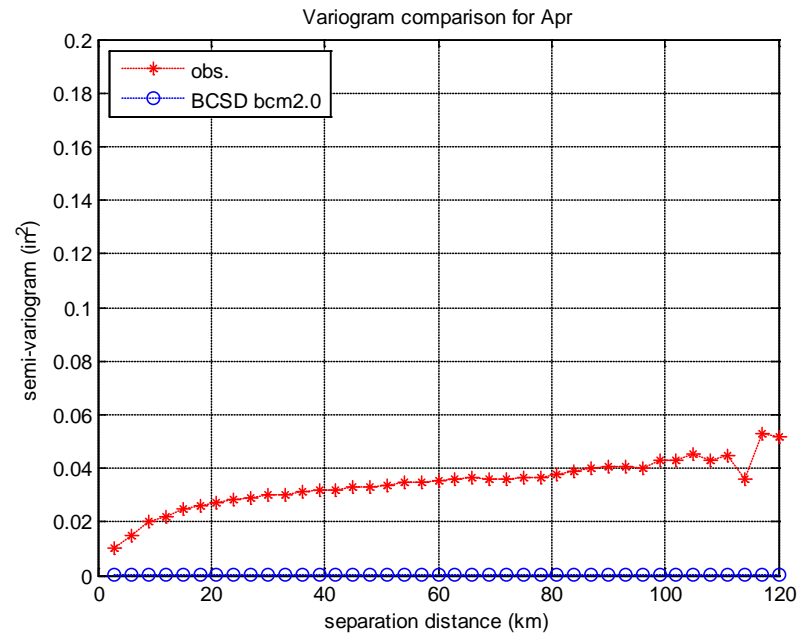
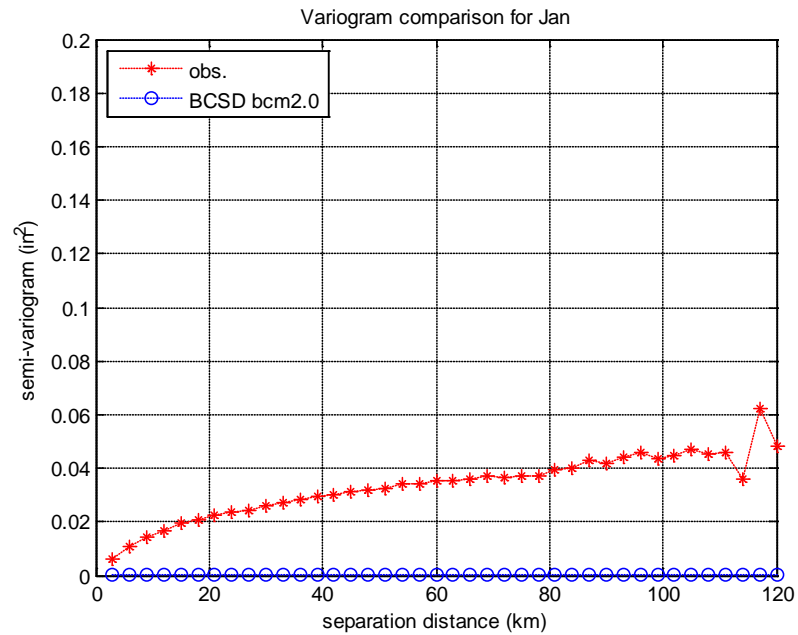


BCSD CMIP3 BCM2.0

190~230 mm

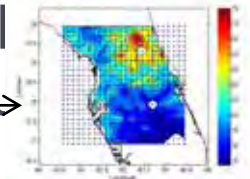
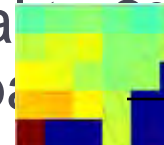
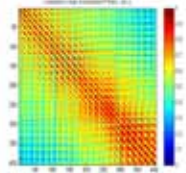
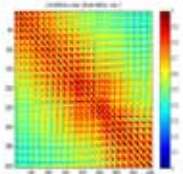


Variogram Comparison (obs. vs. BCSD bcm2.0)

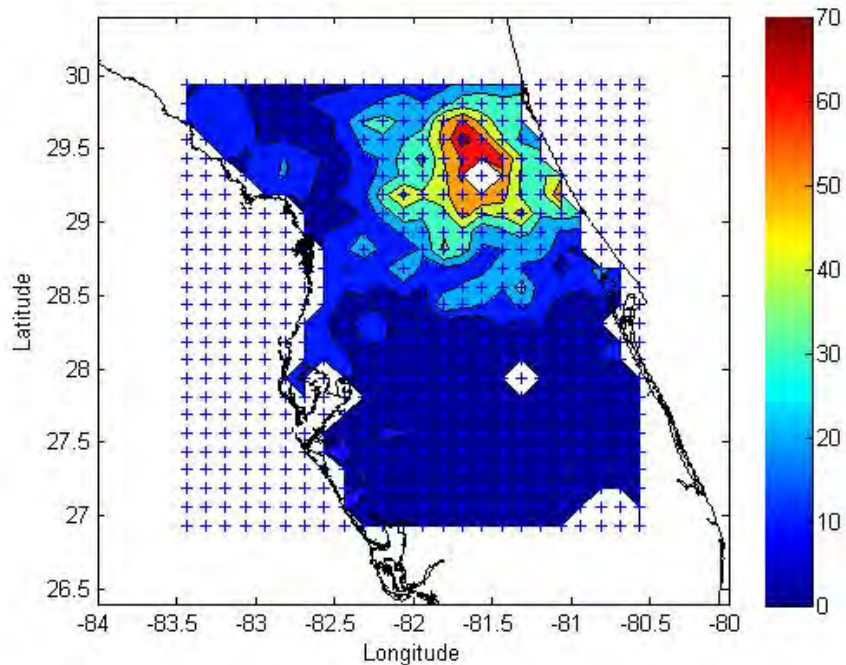


Alternative: Spatially Correlated Disaggregation

- } New spatial disaggregation technique developed to improve small-scale spatial correlation structure of rainfall
- } Take normal score transform of observed daily precipitation data at each station
- } Estimate spatial covariance of normal score transform data over all stations
- } Use LU decomposition method to generate an ensemble of normal-score fields that honor observed spatial covariance
- } Back transform normal-score fields to generate an ensemble of spatially distributed precipitation fields
- } For each daily GCM prediction randomly select realization from ensemble with spatial mean equal to GCM prediction but observed small-scale spatial structure

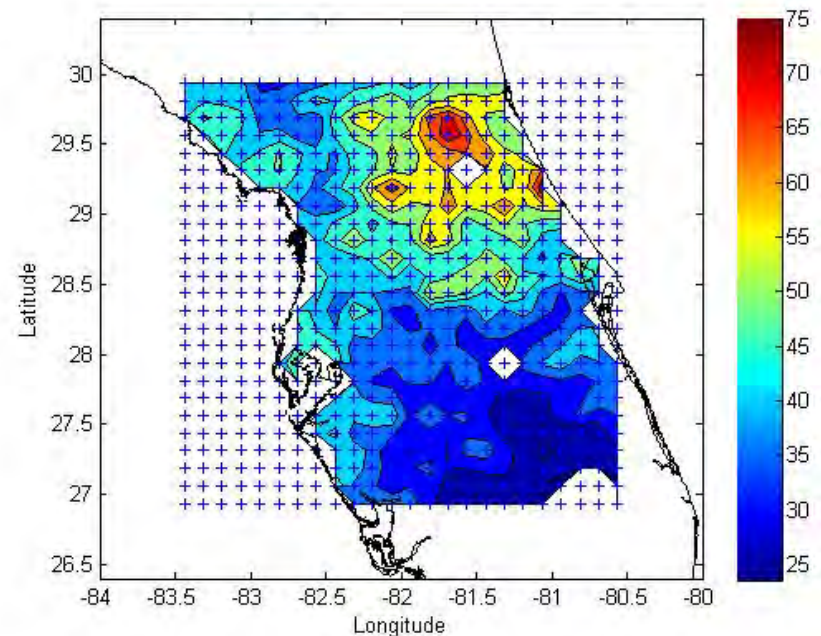


Example of spatial distribution

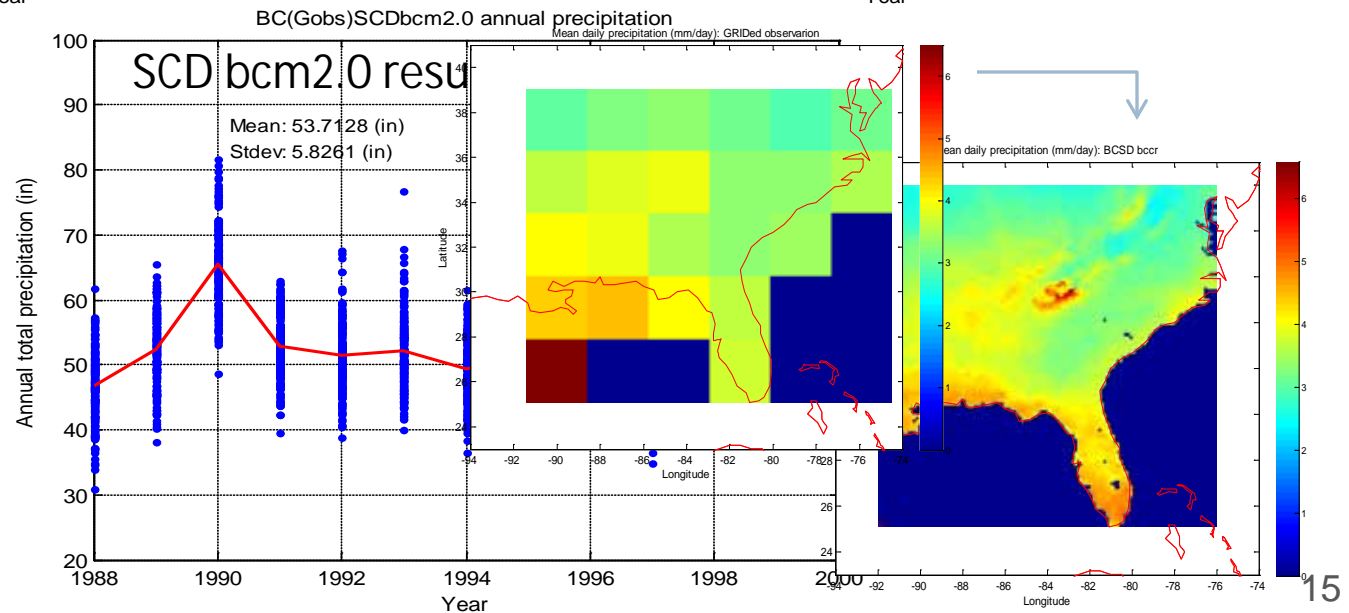
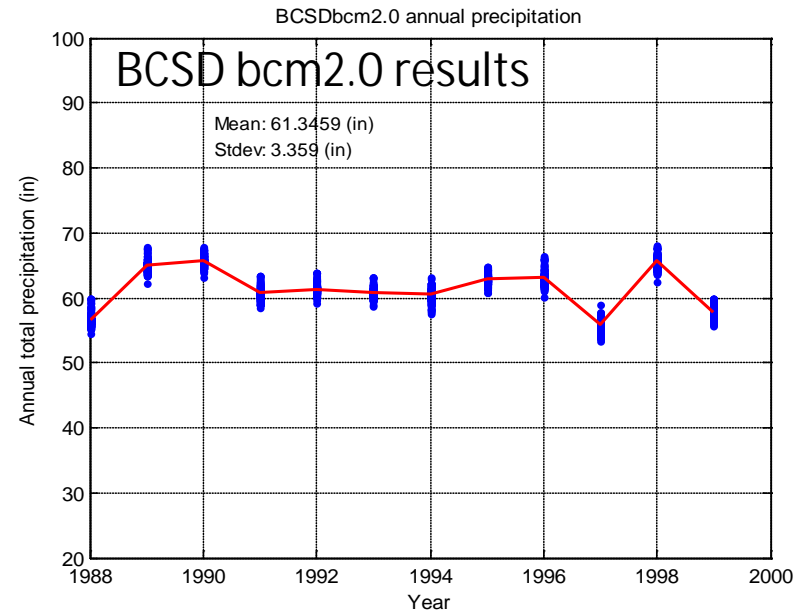
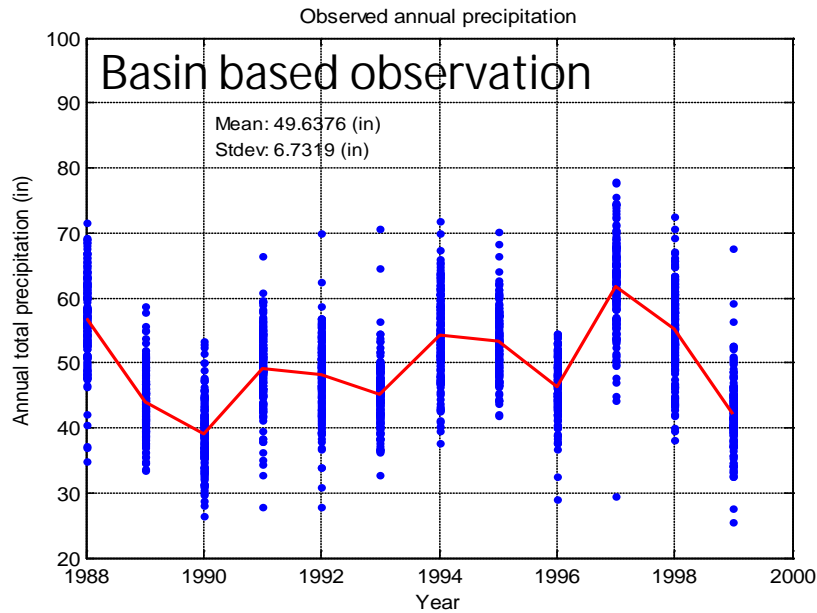


Spatial distribution of CMIP3 rainfall field disaggregated with **SCD** method

Spatial distribution of **BCSD** CMIP3 rainfall field

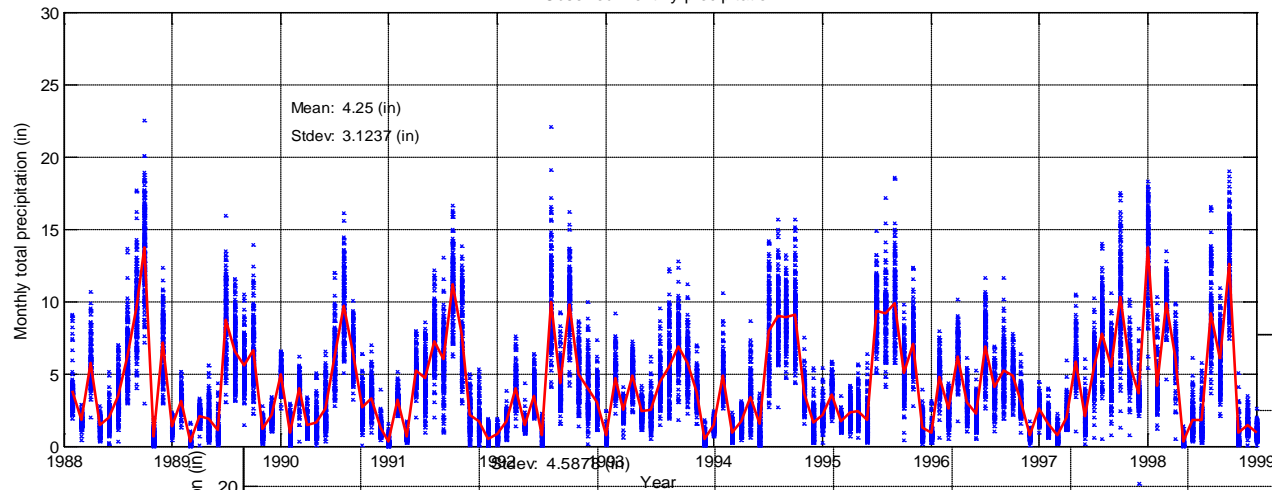


Annual precipitation comparison



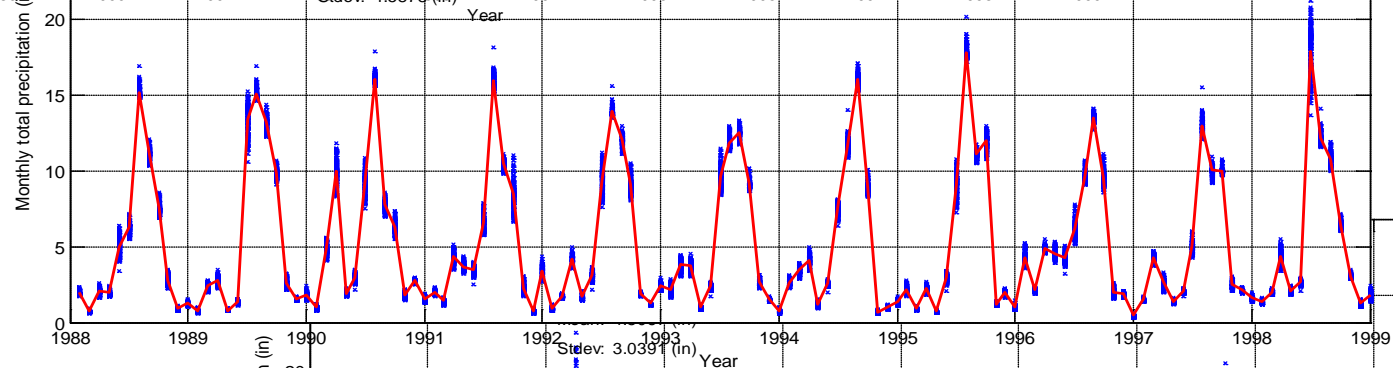
Monthly precipitation comparison

Observed monthly precipitation

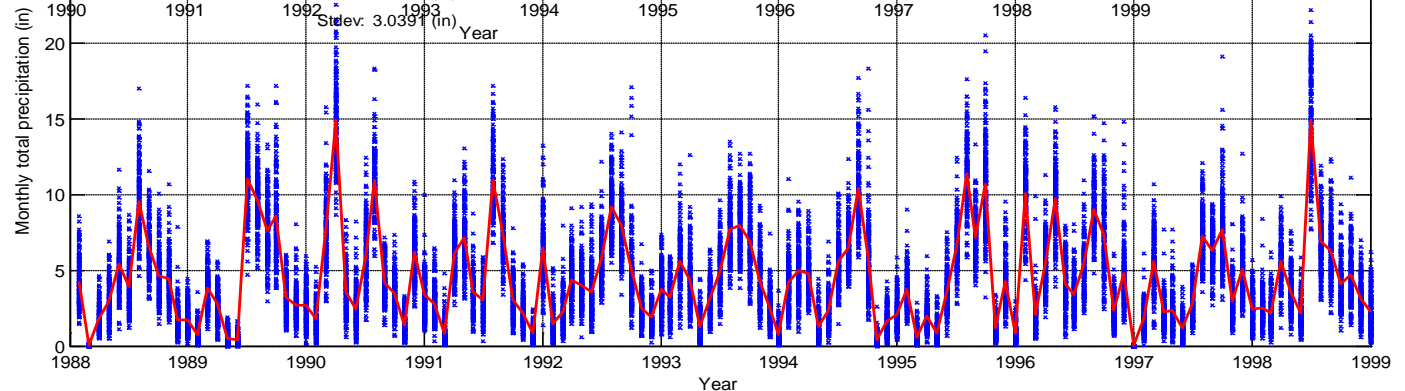


Basin based observation

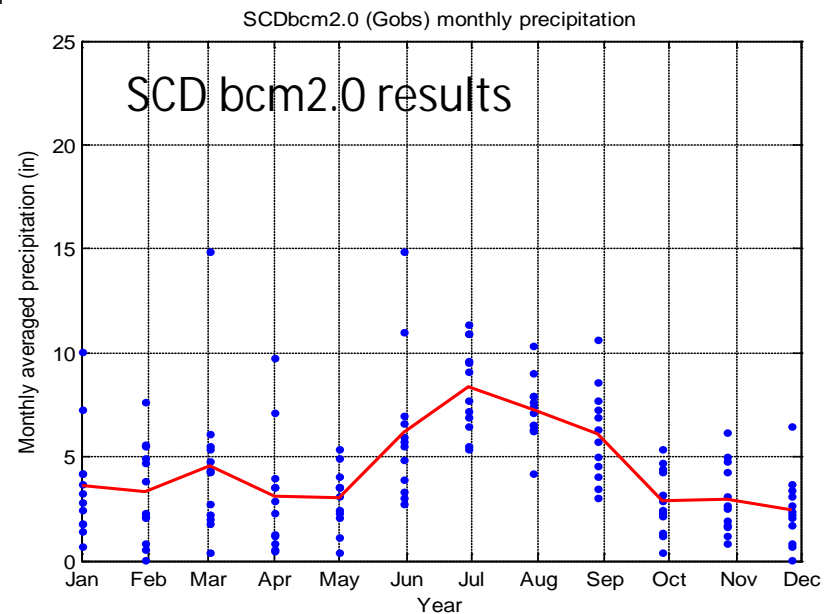
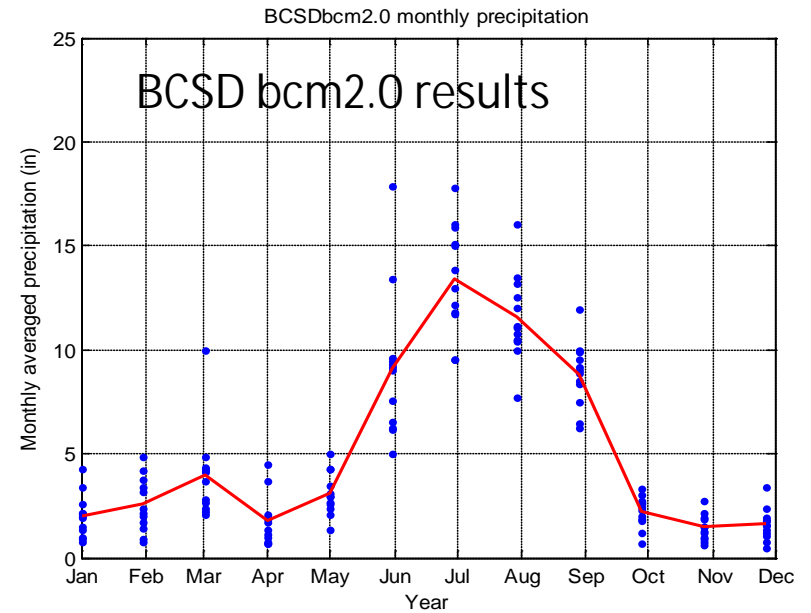
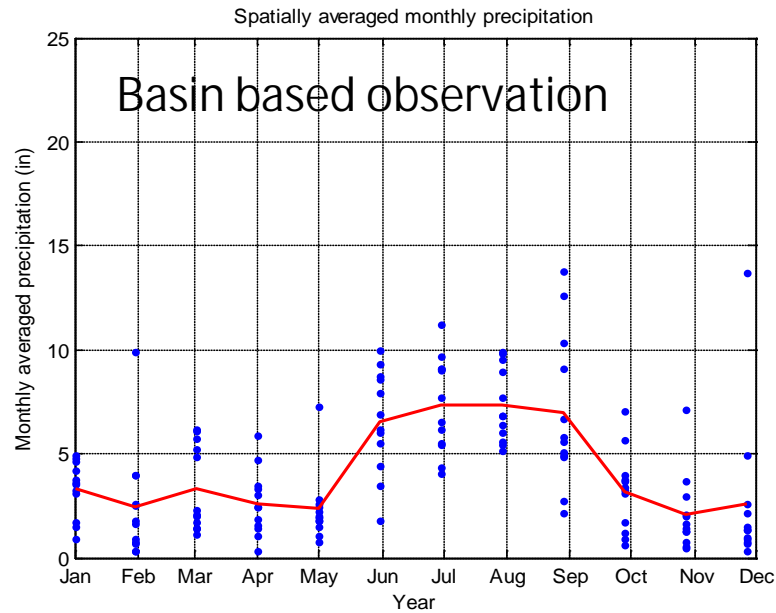
BCSD bcm2.0 results



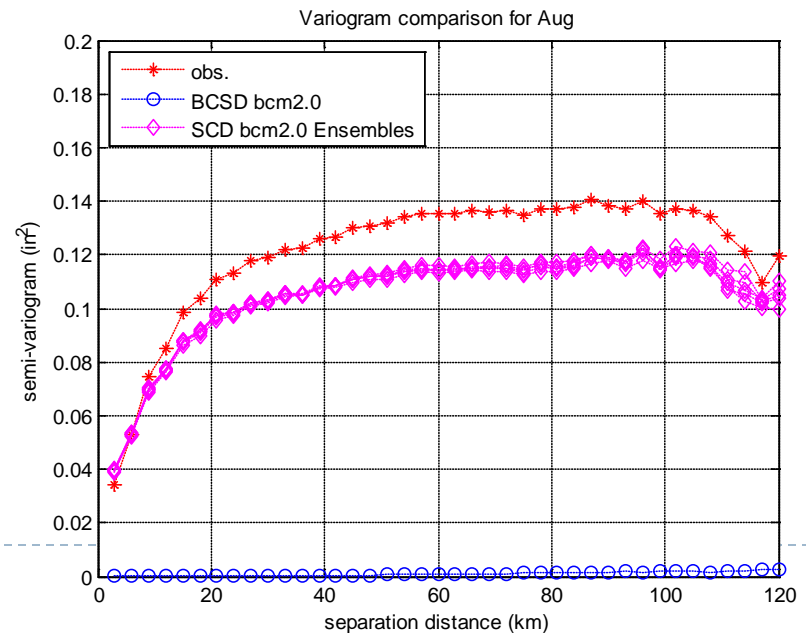
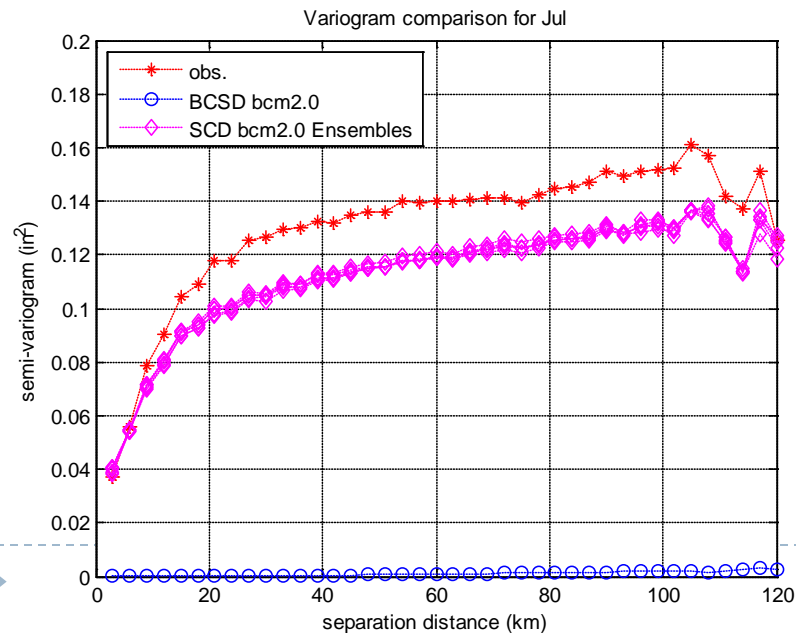
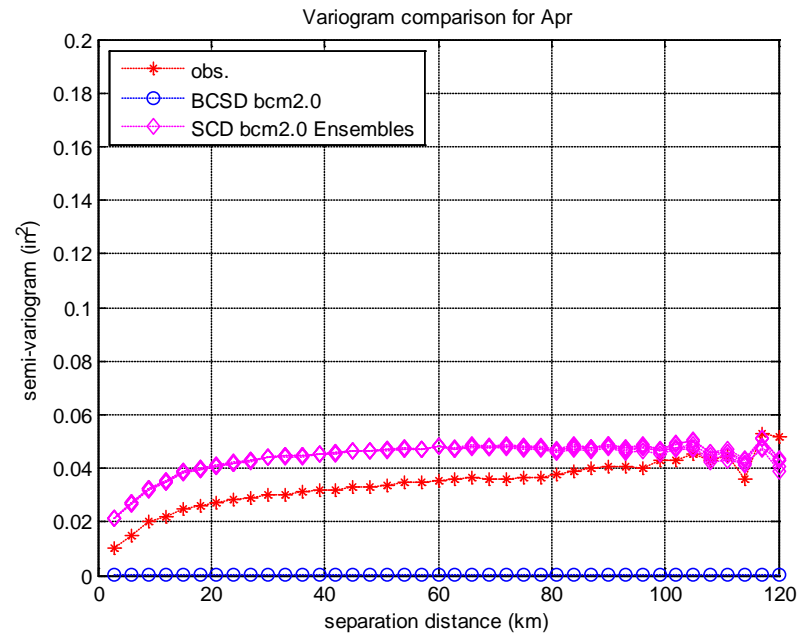
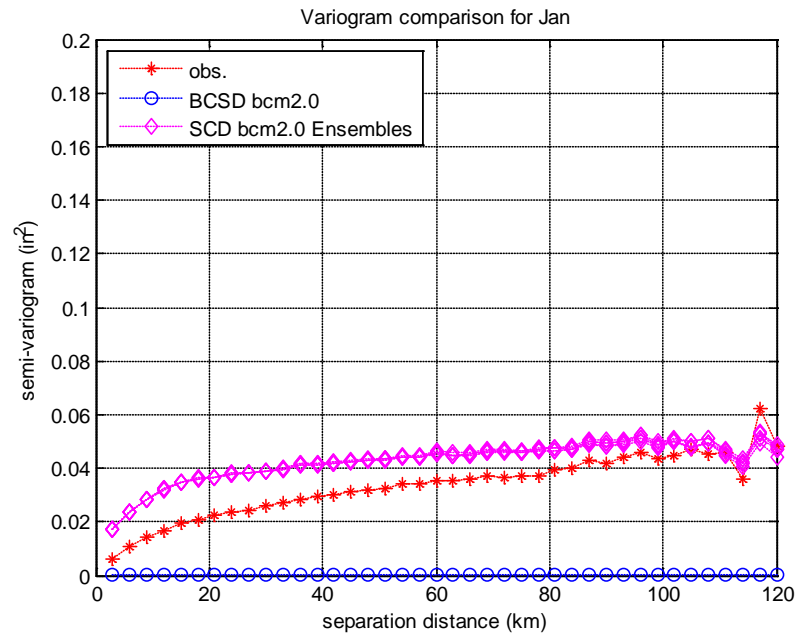
SCD bcm2.0 results



Monthly mean precipitation



Variogram Comparison (obs. vs. BCSD vs. SCD bcm2.0)



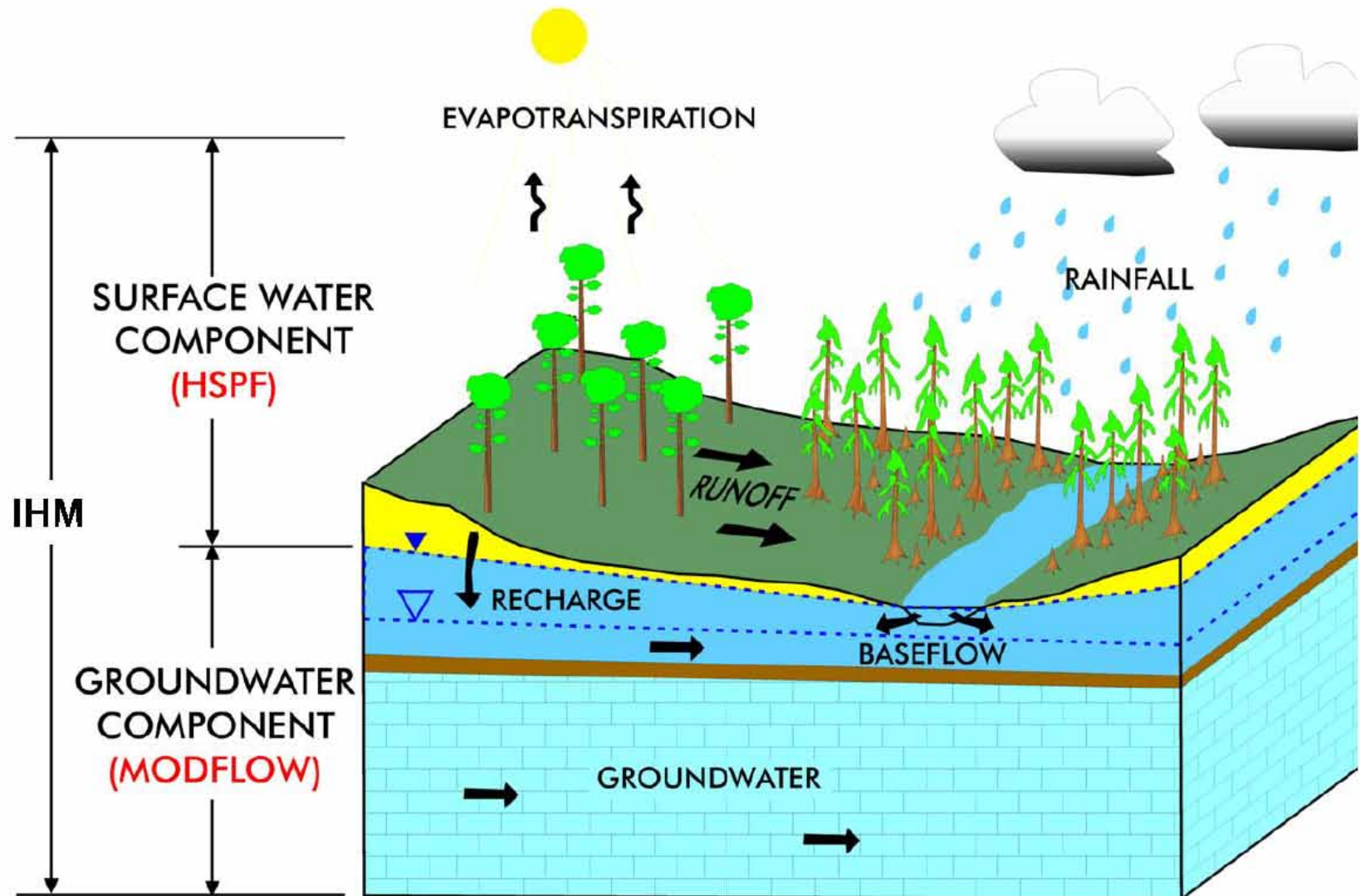
Summary of precipitation analysis for BCM2.0

- } BCSD
 - } Reproduced daily transition probabilities and mean climatology
 - } Underestimated interannual variability in annual rainfall
 - } Significantly underestimated spatial variance and overestimated spatial correlation of precipitation
- } Alternative spatial correlated disaggregation (SCD) method
 - } Improved interannual variability in annual rainfall
 - } Improved spatial variance and spatial correlation structure

IHM simulation results

with GCM (BCM2.0) results

Conceptual View of HSPF & MODFLOW within IHM



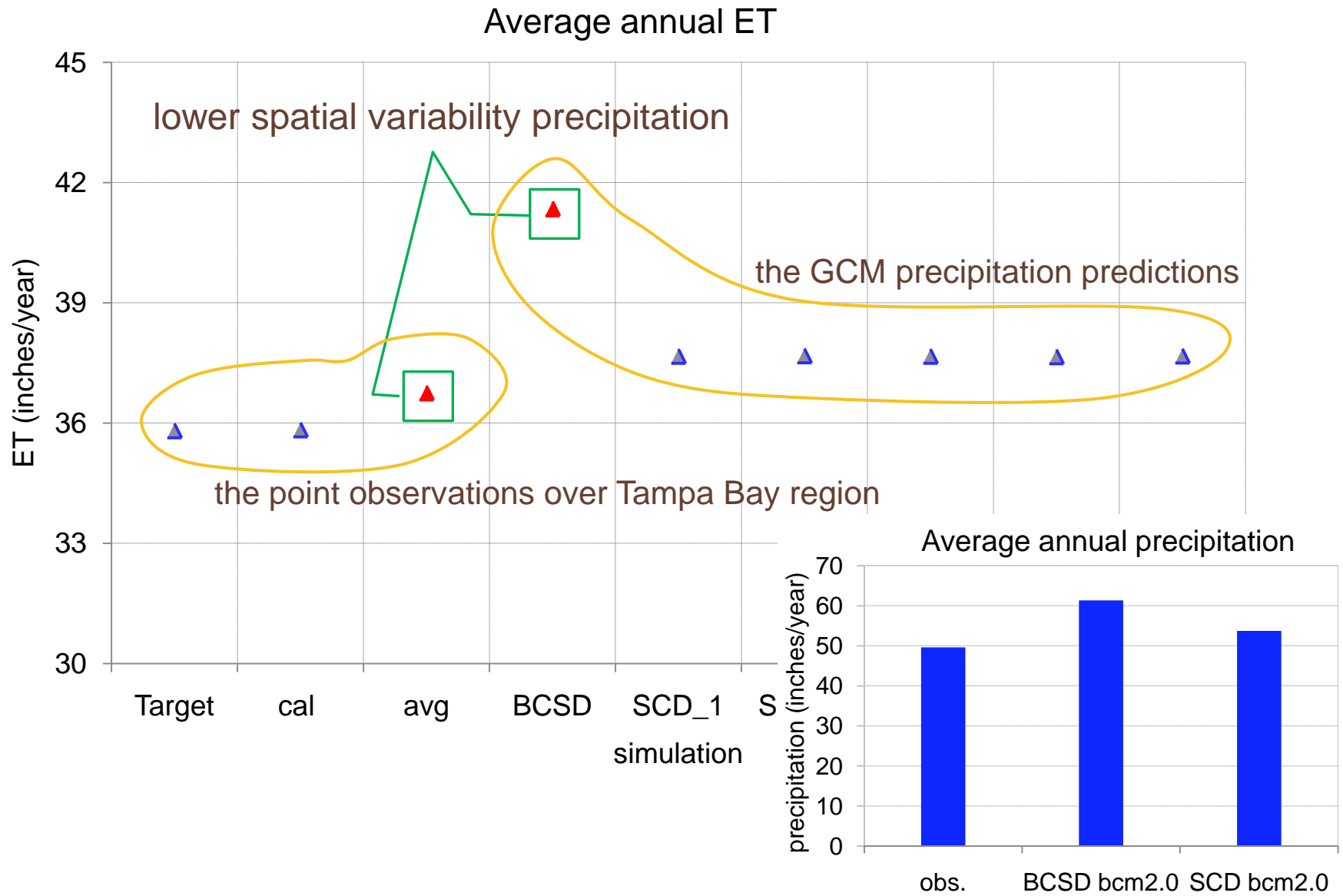
The purposes are to...

- } Evaluate hydrologic importance of accurately representing the spatiotemporal characteristics of precipitation fields using Tampa Bay Water's Integrated Hydrologic Model (IHM)
- } Evaluate the ability of bias-corrected and spatially-disaggregated GCM retrospective simulations (CMIP3) to reproduce observed hydrologic behavior using IHM
- } Evaluate changes in hydrologic behavior that result from driving the IHM with bias-corrected and spatially disaggregated GCM future predictions

IHM modeling runs:

Run	Precipitation	Temperature	Production	Diversion	Irrigation
1	Obs. (89'-97')	Obs.	Obs.	Obs.	Obs.
2	Spatially Averaged	Obs.	Obs.	Obs.	Obs.
3	BCSD_BCM2.0 (89'-97')	BCSD_GCM	Obs.	Obs.	Obs.
4	SCD_BCM2.0 (89'-97': 5 realizations)	BCSD_GCM	Obs.	Obs.	Obs.

Simulated average annual Rainfall & ET over the domain

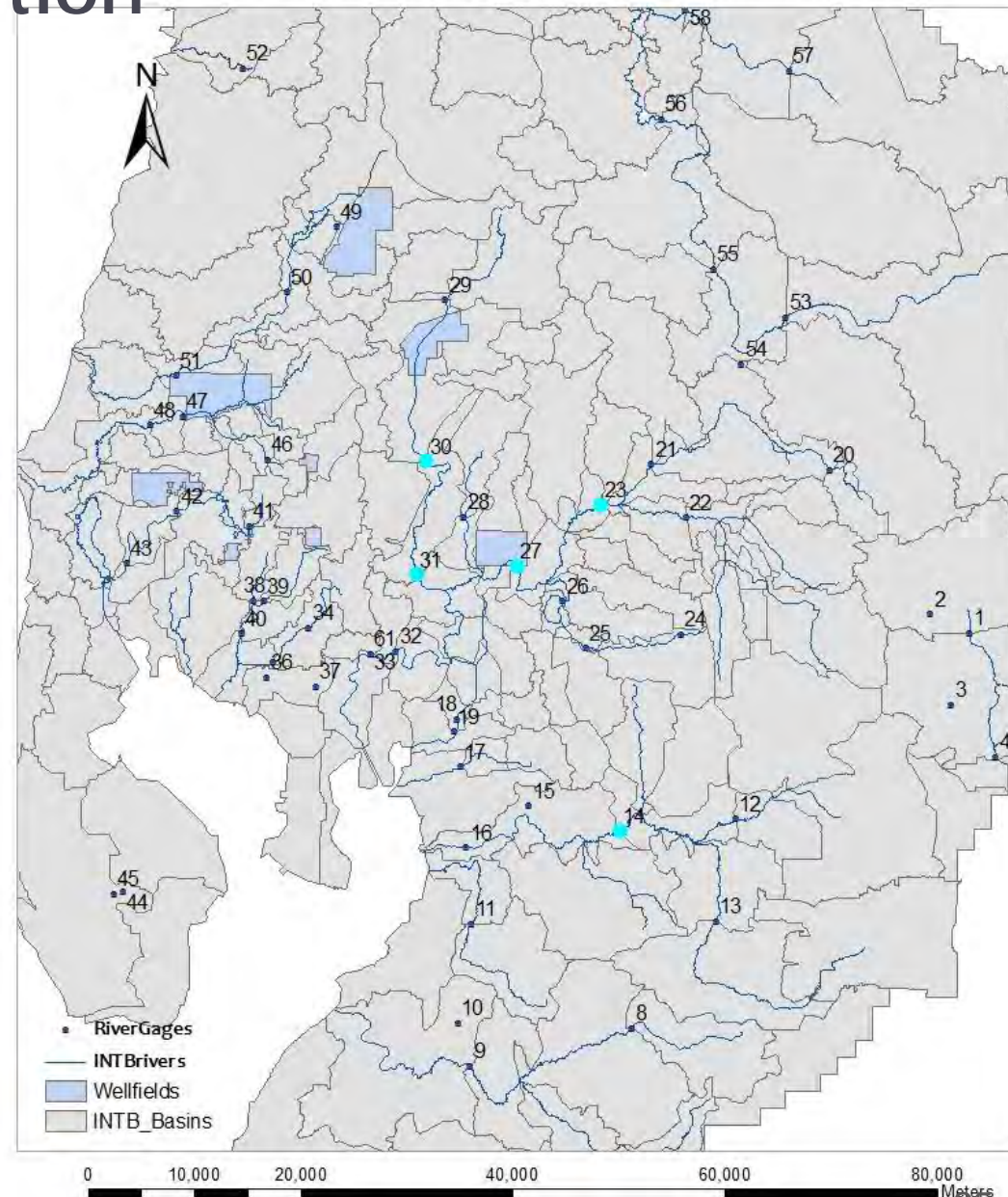


1. Streamflow evaluation

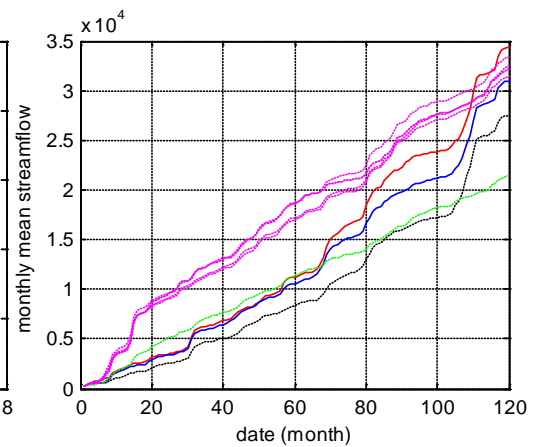
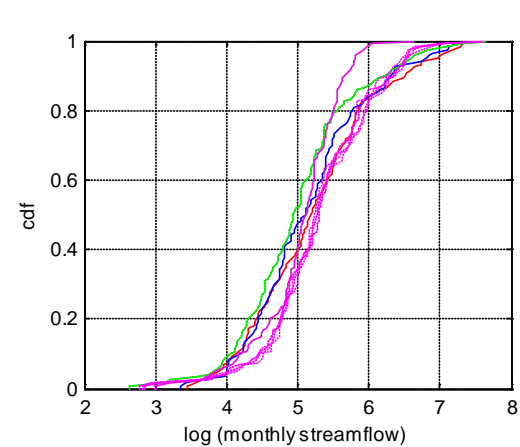
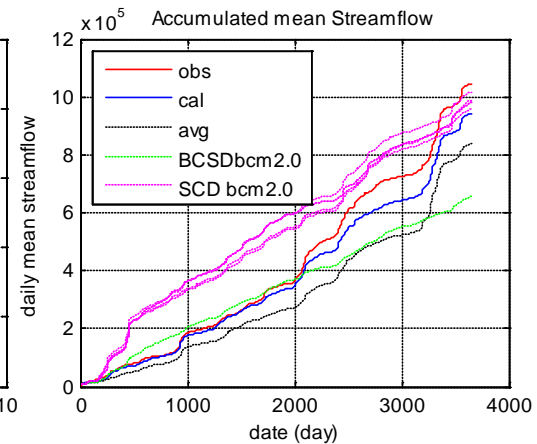
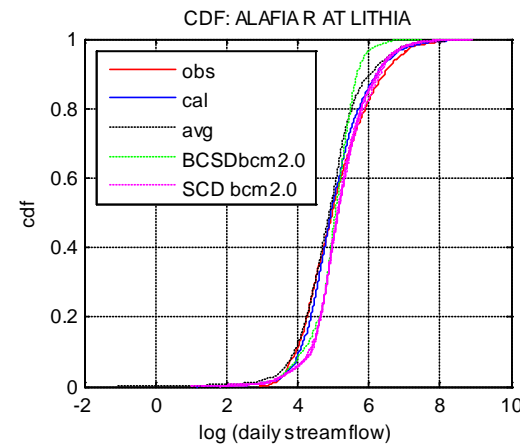
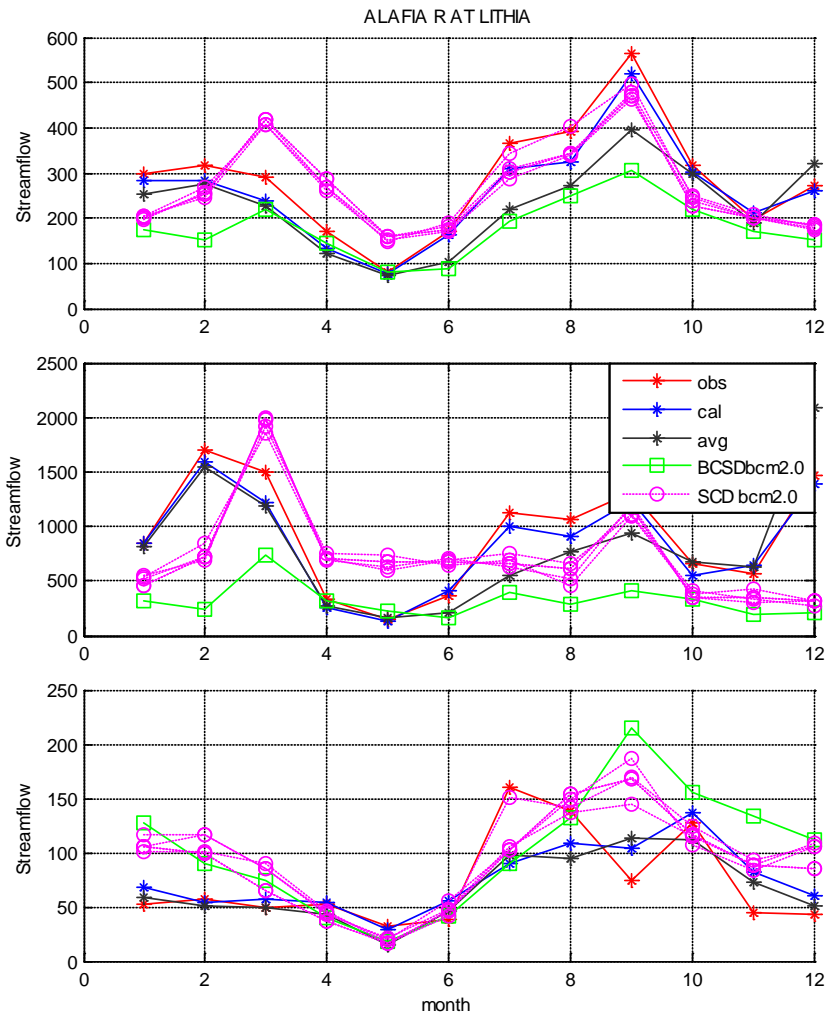
Streamflow gages for evaluation

} Target stations

1. Alafia at Lithia (14)
2. Cypress Creek at Worthington (30)
3. Cypress Creek near Sulfur spring (31)
4. Hillsborough river at Morris Bridge (27)
5. Hillsborough river at Zephyrhills (23)
6. Anclote river near Elfers
7. Anclote river near Odessa



Results for Alafia at Lithia

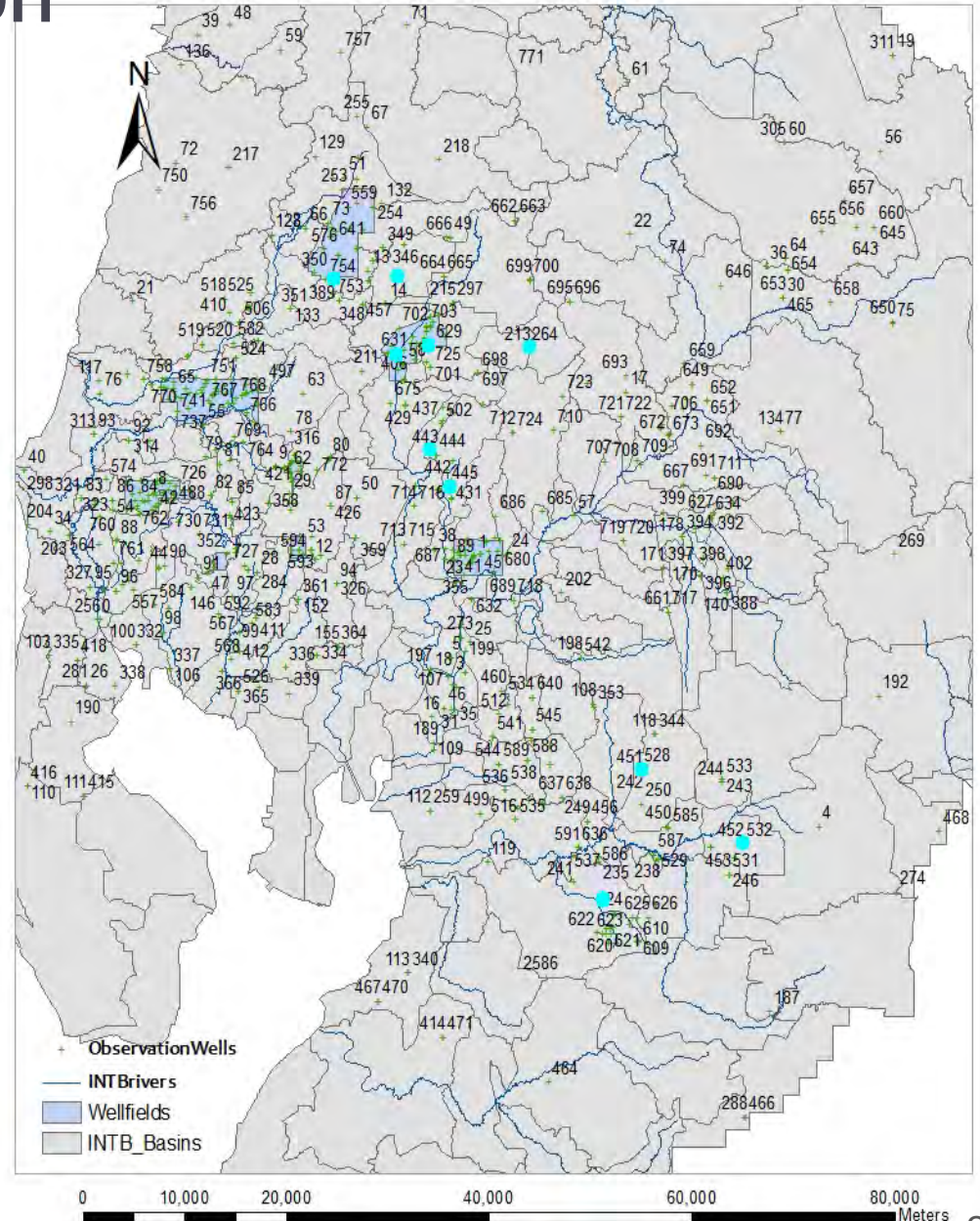


2. Aquifer evaluation

Aquifer stations for evaluation

} Target stations

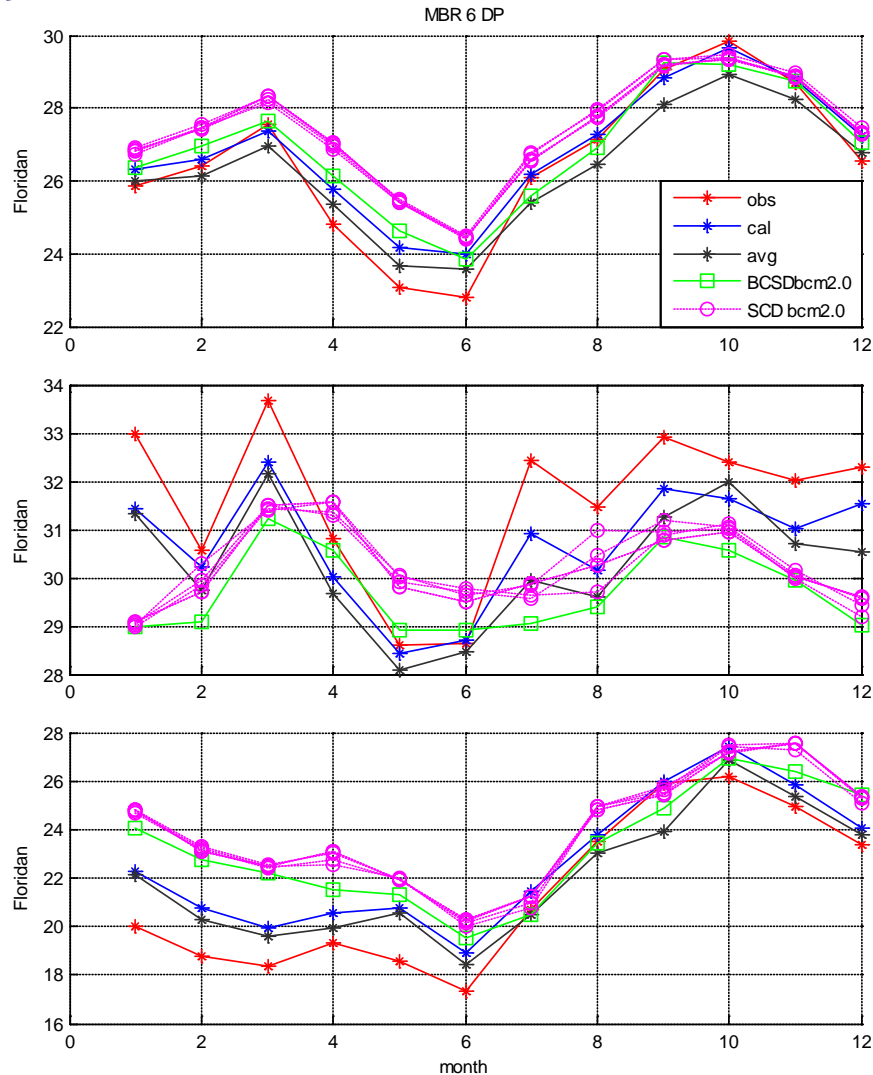
13 pairs of groundwater level stations for Floridan and Surficial aquifer are selected to evaluate the results



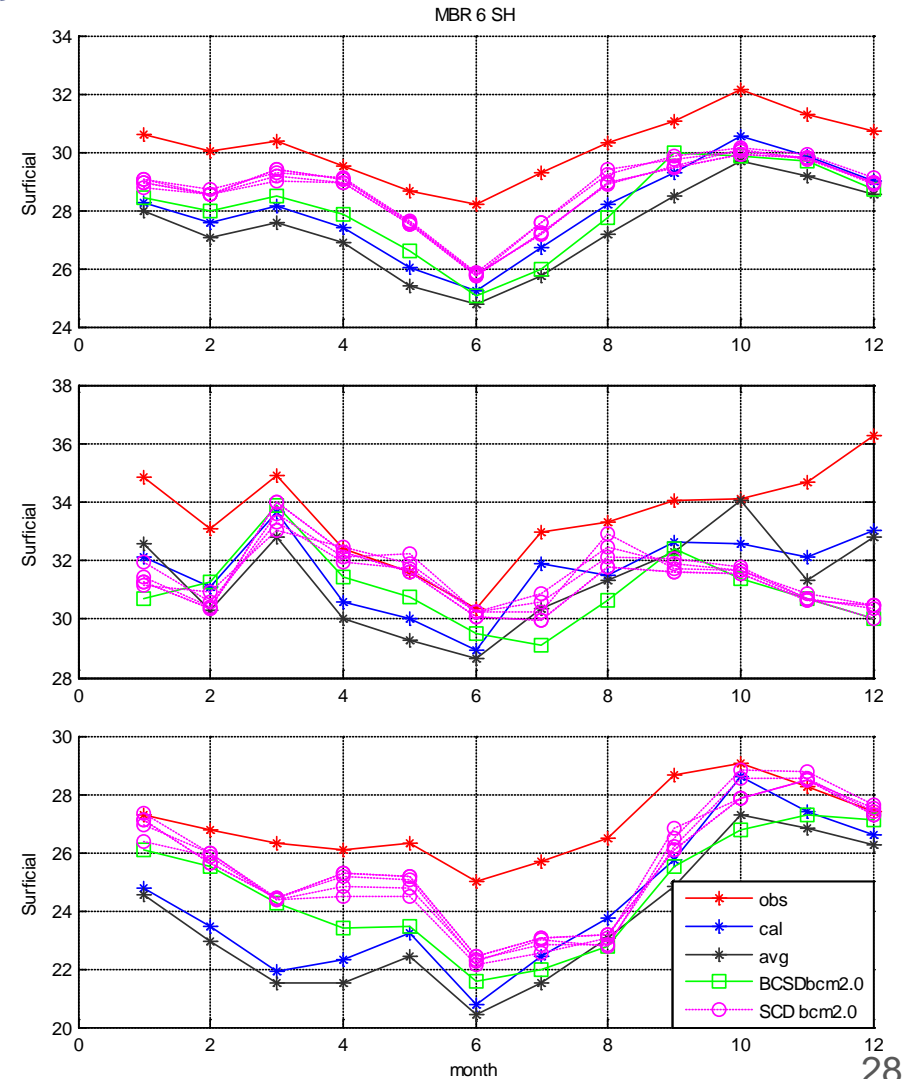
Comparison of the mean, maximum, and minimum monthly averaged groundwater level for each month

Seasonal groundwater level

} 1. Floridan



} 2. Surficial

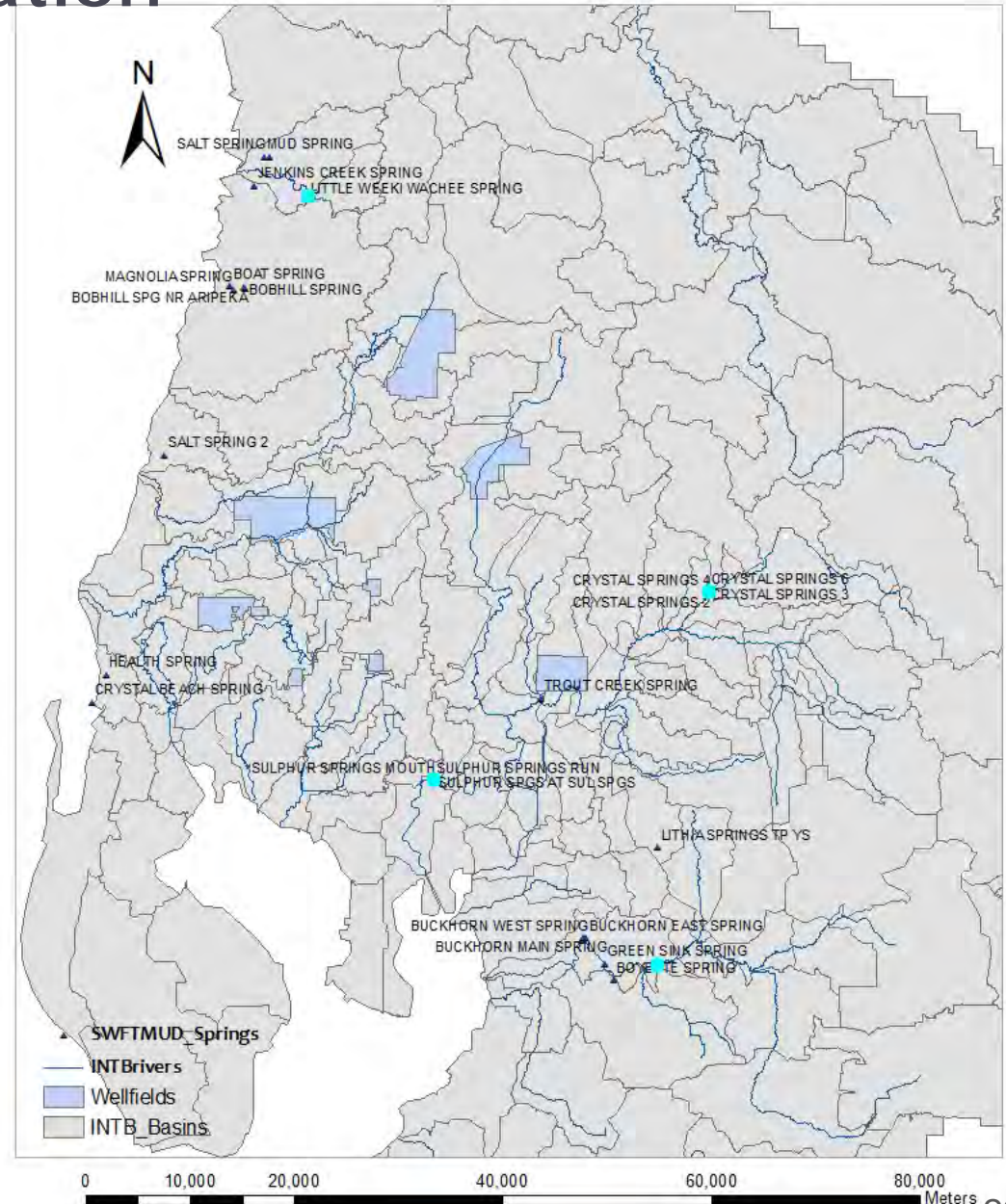


3. Springflow evaluation

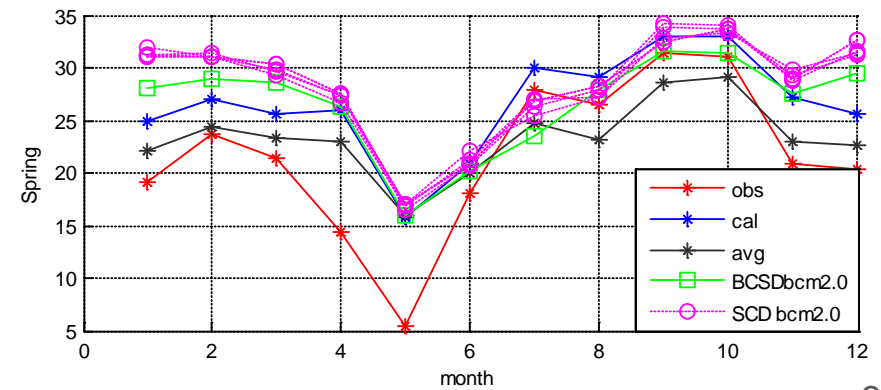
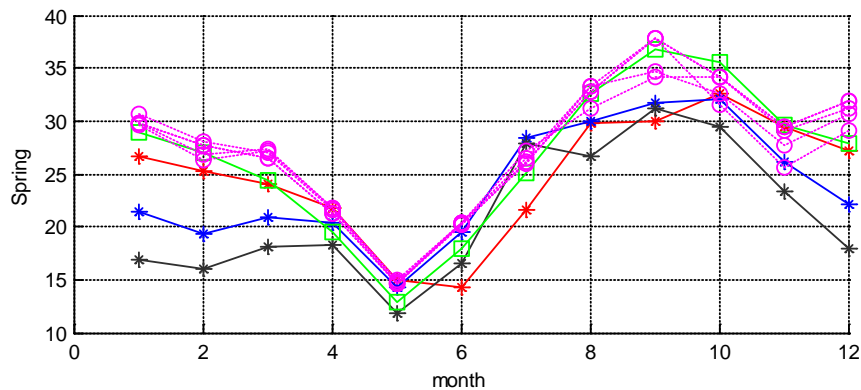
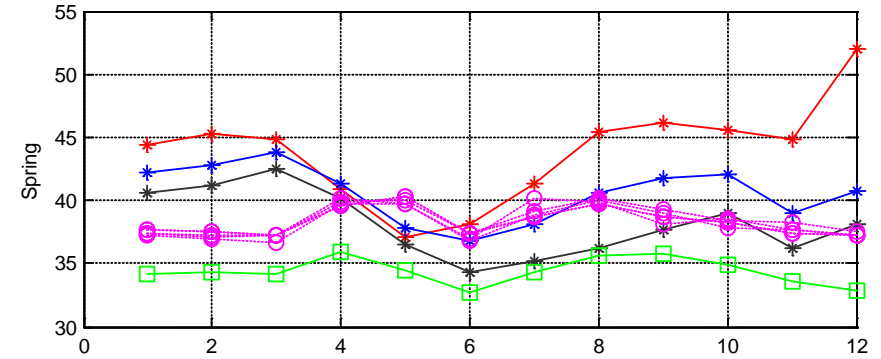
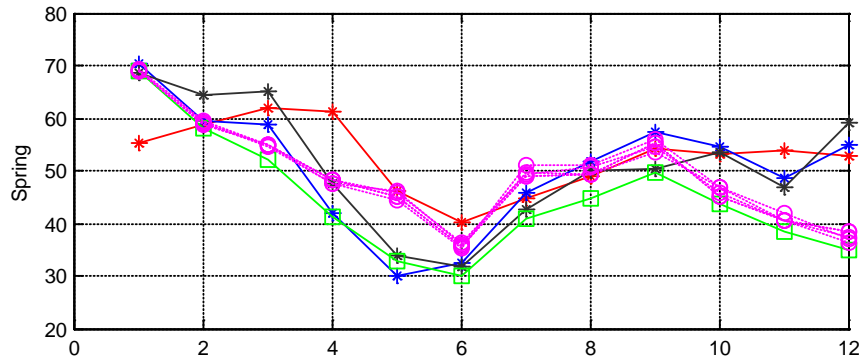
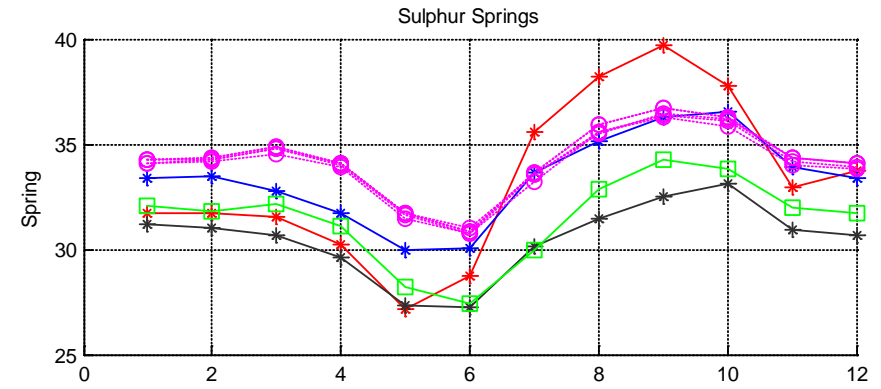
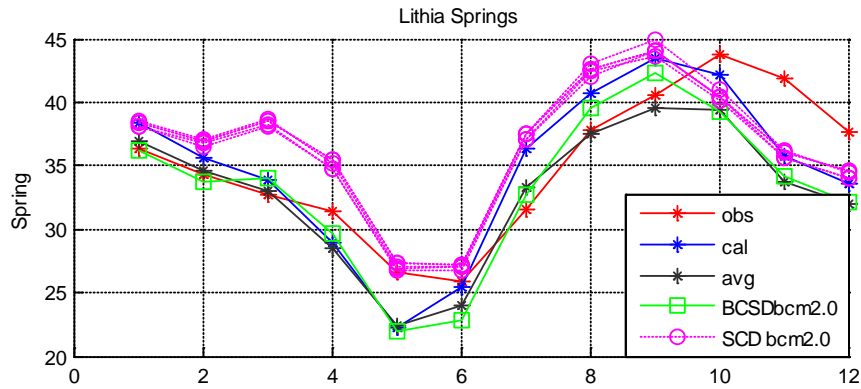
Springflow gages for evaluation

} Target stations

1. Cristal spring
2. Weeki Wachee spring
3. Sulphur spring
4. Lithia spring



Springflow simulation results for two station



Conclusions

- } The calibrated IHM model accurately reproduces observed streamflow, springflow, ground water level, and water balance over the domain for '89-'97.
- } SCD BCM2.0 results generally reproduce observed hydrologic behavior (i.e. average monthly streamflow, springflow and groundwater levels and accumulated streamflow) compared to observed and calibrated IHM results.
- } Due to low spatial variability of precipitation, IHM simulations with spatially averaged precipitation and BCSD BCM2.0 results tend to
 - } Predict higher average annual ET compared to calibrated and SCD BCM2.0 results
 - } Predict lower streamflow, springflow compared to calibrated and SCD results.
 - } Predict significantly lower total surface water availability (i.e., low accumulated streamflow predicted over simulation period)

Questions?

