Evaluation of dynamically and statistically downscaled climate model results

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

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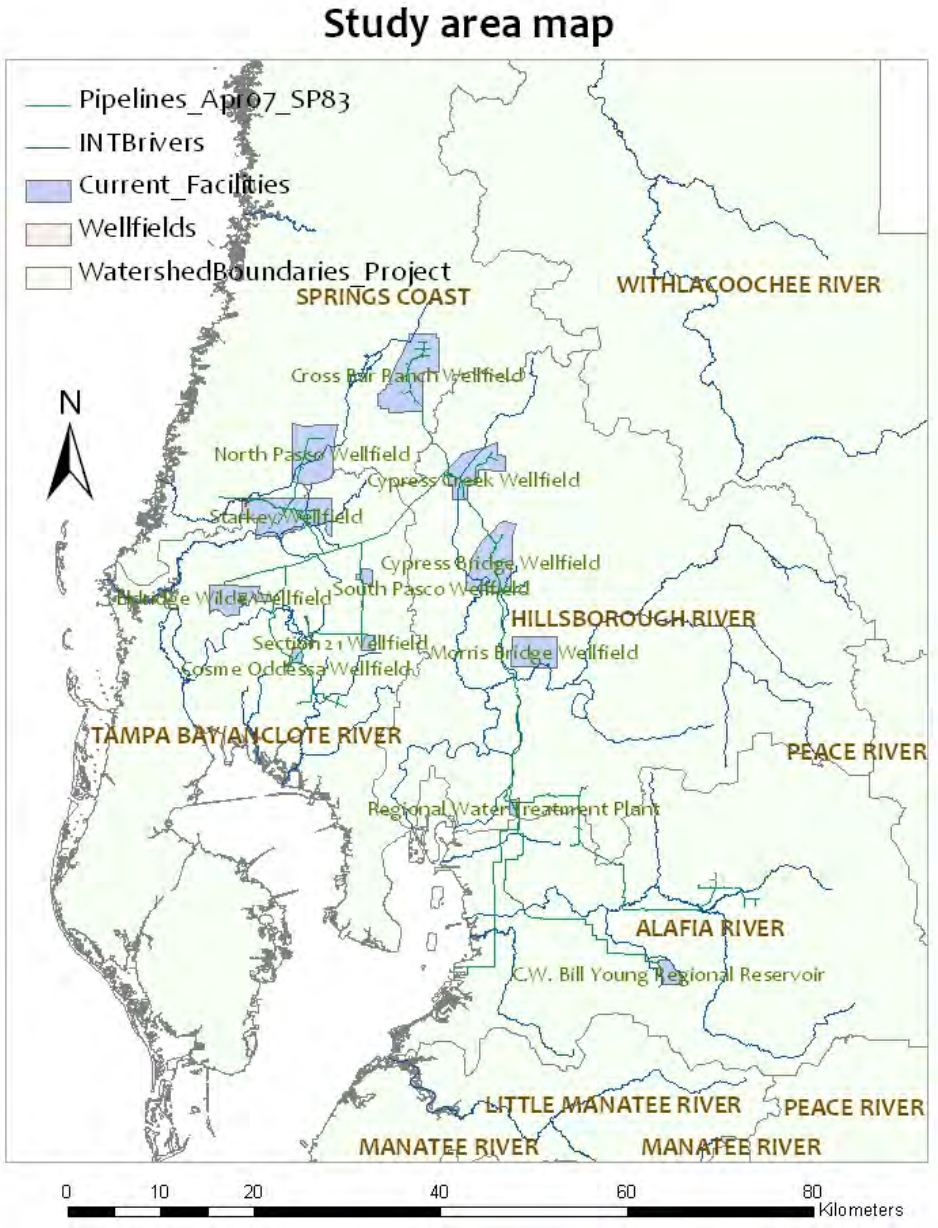
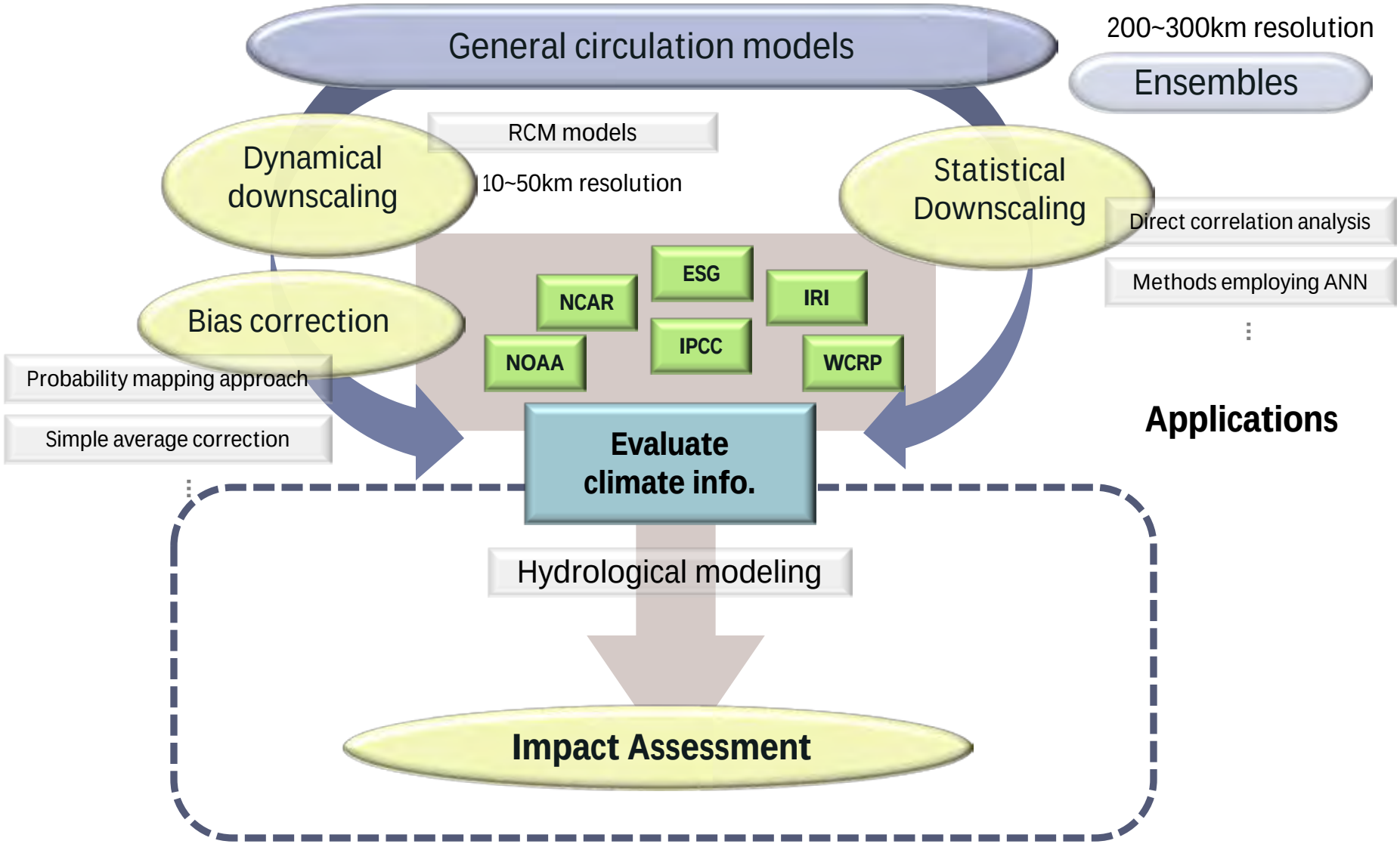
Tampa Bay Water

…. 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



BIG PICTURE


General circulation models
200~300km resolution
Ensembles
Dynamical downscaling
RCM models
10~50km resolution
Statistical Downscaling
Direct correlation analysis
Methods employing ANN
Bias correction
Probability mapping approach
Simple average correction
ESG
NCAR
IRI
IPCC
NOAA
WCRP
Applications
Evaluate climate info.
Hydrological modeling
Impact Assessment

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)

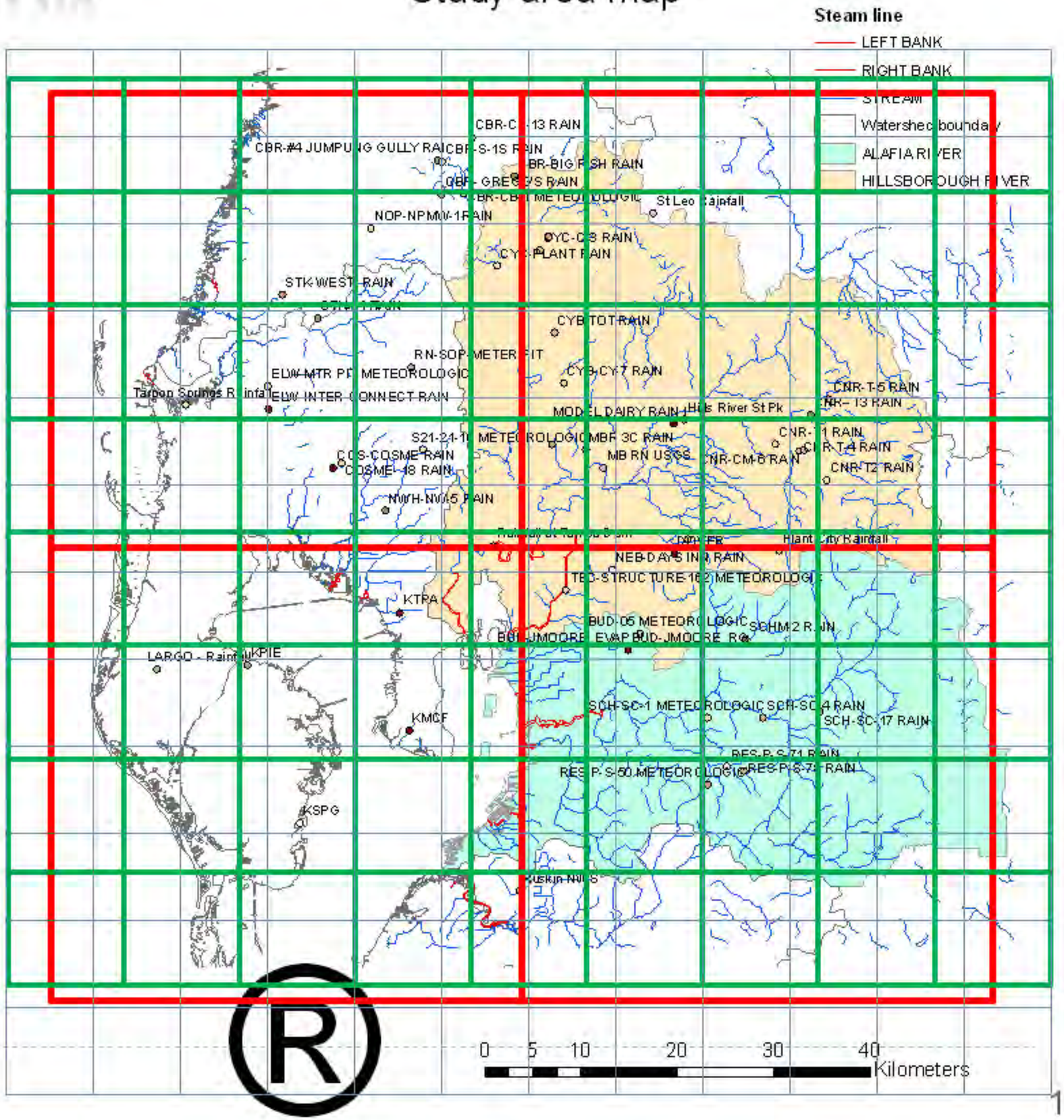
SPATIAL RESOLUTION

MM5
downscaled results
(9km× 9km)

BCSD CMIP3 data
(12km × 12km)

NNARCCAP data
(50km × 50km)

Study area map



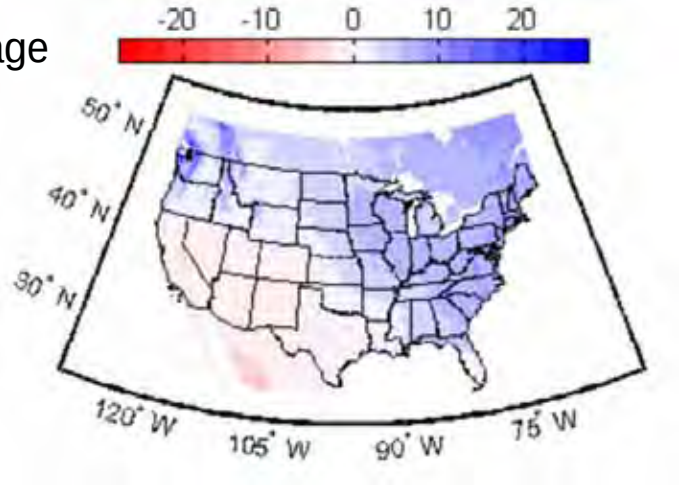
IHM modeling Plans

		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

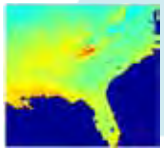
WCRP CMIP3

- 16 GCMs (1950~1999 & 2000~2099)
- 3 scenarios for future greenhouse gas emissions
- Bias correction
  - probability mapping approach
    - Wood et al. (2004)
- Statistical downscaling
  - 1/8° grid =12km resolution
    - Maurer, E.P. (2002).

Spatial Coverage

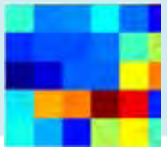


BCSD CMIP3 (Daily disaggregation method)



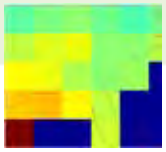
Observationally based daily gridded dataset: spatial resolution of 1/8° (~12 km)

GCM's daily simulation of 20th century climate : spatial resolution of 2.8°



Aggregate to 2° spatial resolution

Spatially interpolate GCM gridded time series data to a 2° spatial resolution



Bias correction: CDF construction & matching

Bias corrected GCM dataset

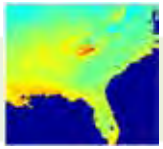
Compute factor values at each 2° grid point in the domain
Factor=bias corrected 2° GCM/aggregated 2° monthly mean

calculate given month's 1950-1999 mean from the observational dataset (2° resolution)

2° GCM factor

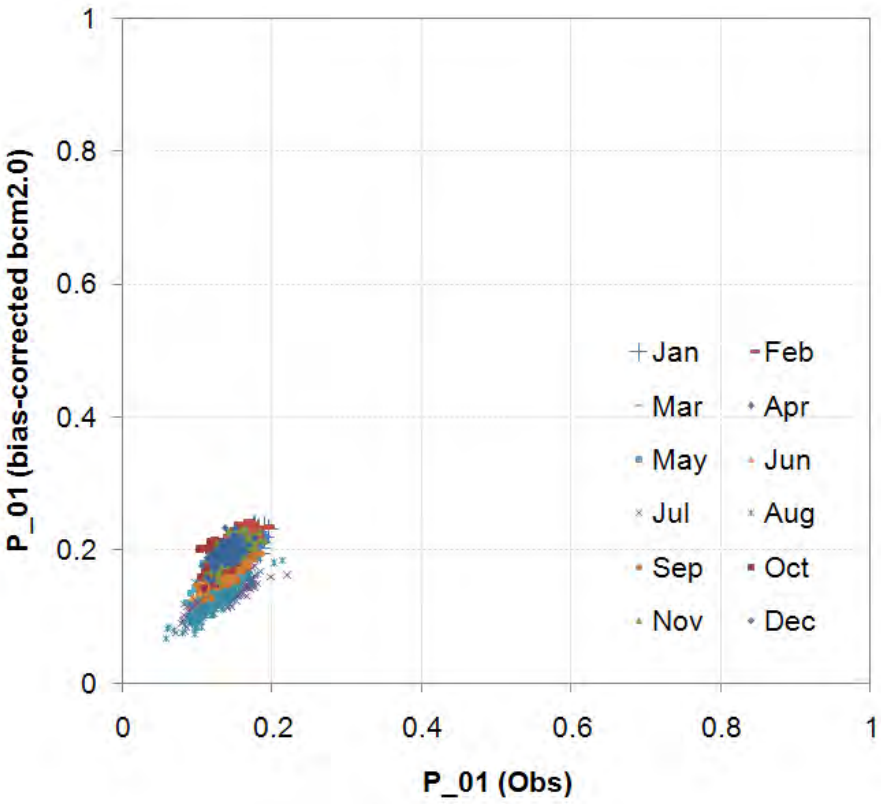
Interpolate the 2° GCM factor values to 1/8° resolution using a modified inverse-distance-squared interpolation

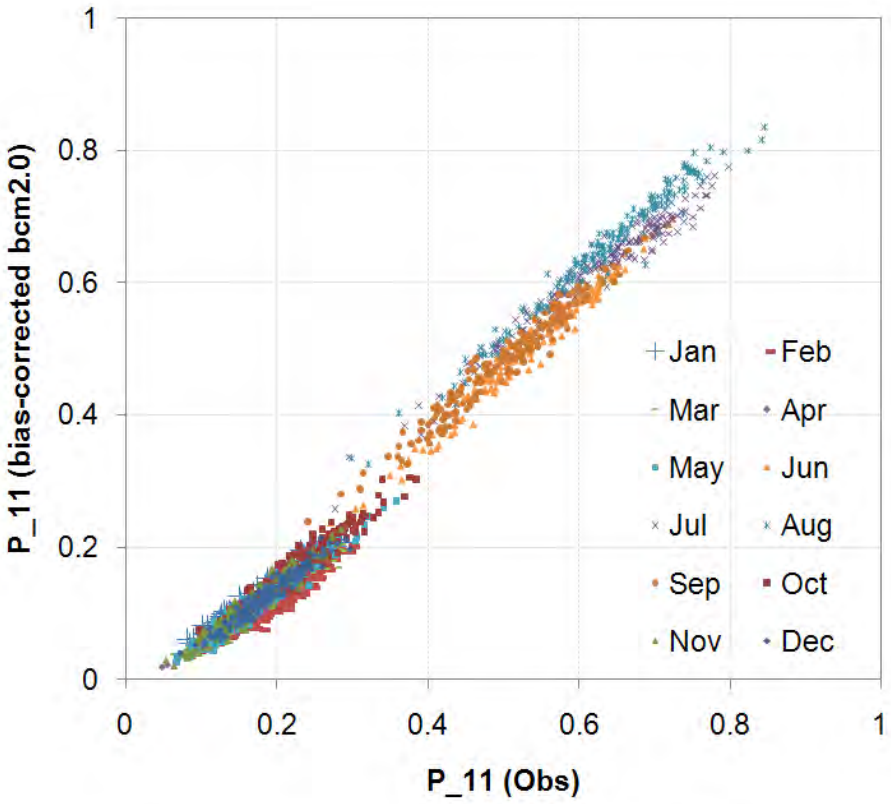
Multiply 1/8° GCM factors by observed 1/8° observed mean



Bias corrected and spatially downscaled 1/8°prediction

BCSD CMIP3 BCM2.0 vs Observed Transition Probabilities

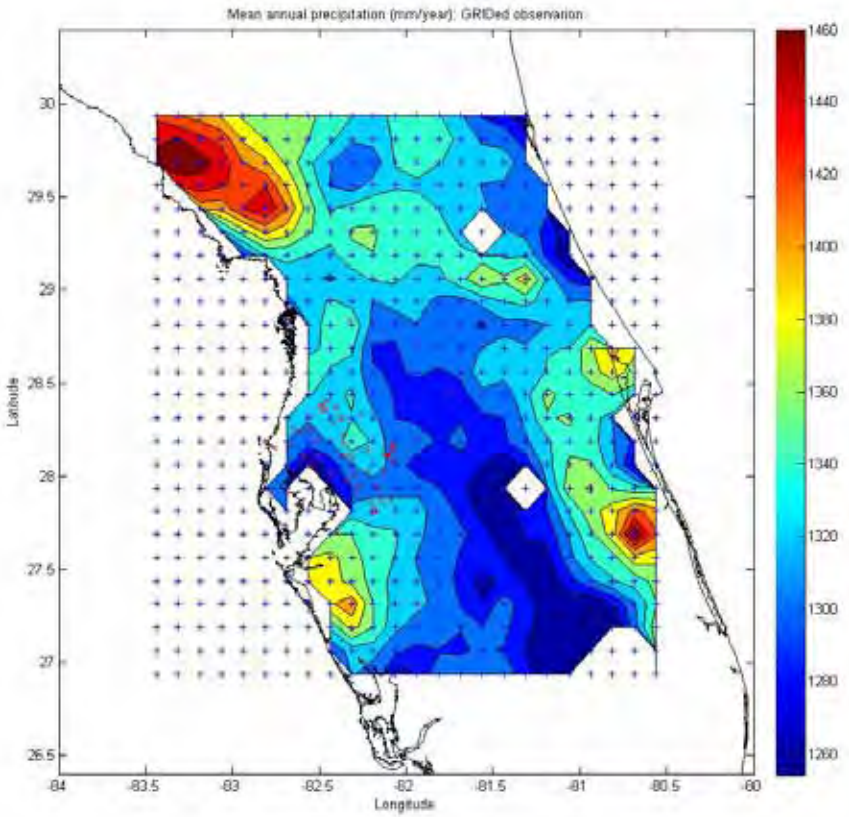




Mean Annual Precipitation (1961-1999)

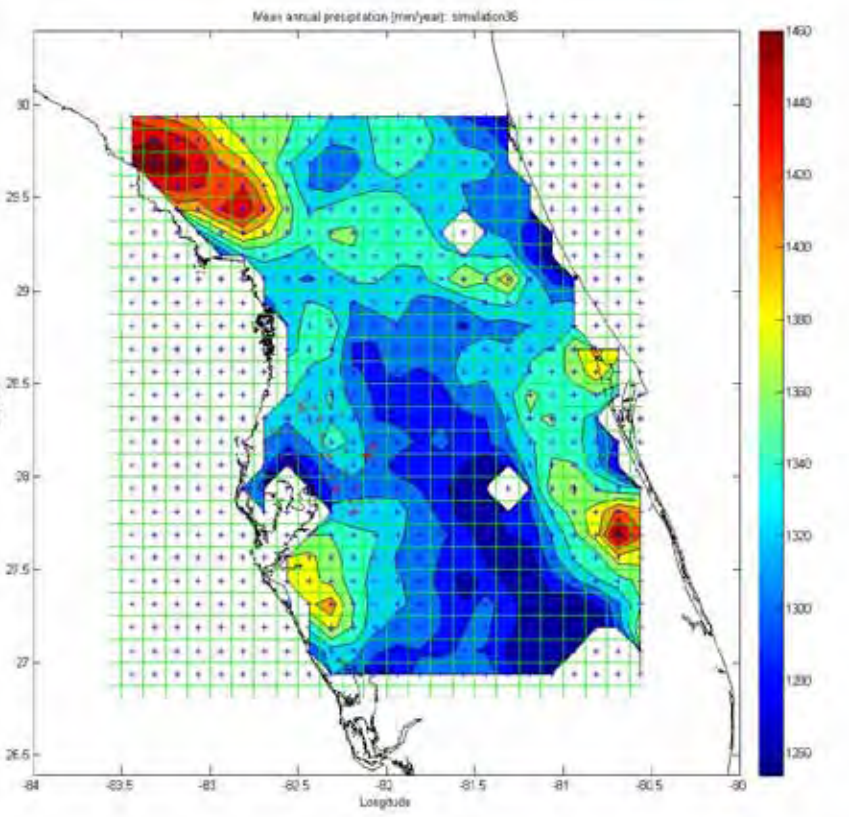
Gridded observation

1260~1460 mm



BCSD CMIP3 BCM2.0

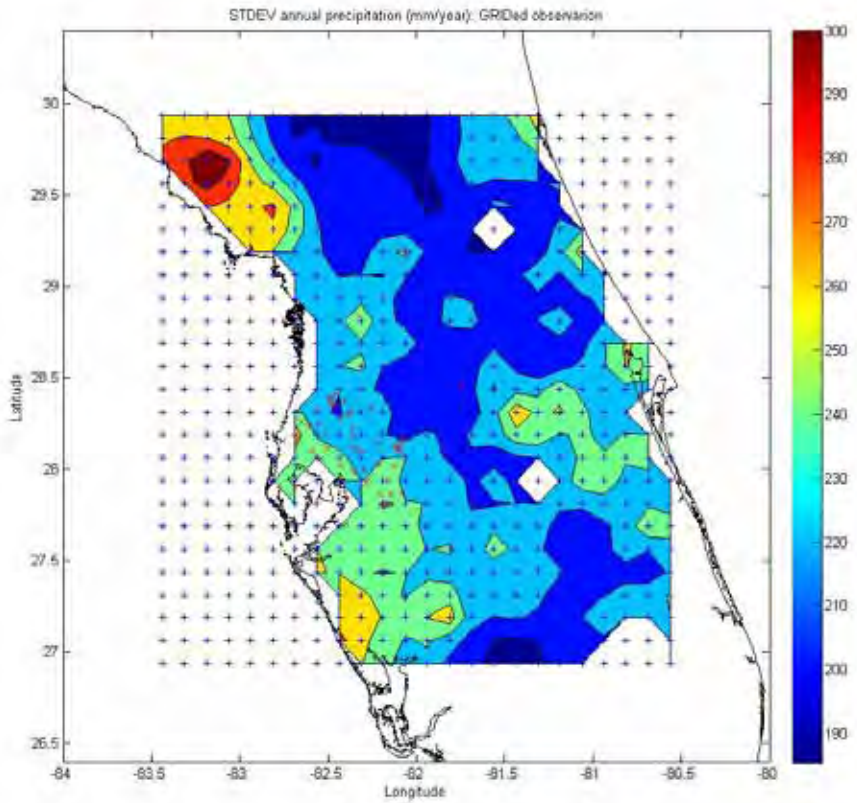
1260~1460 mm



Std Dev of Annual Precipitation (1961-1999)

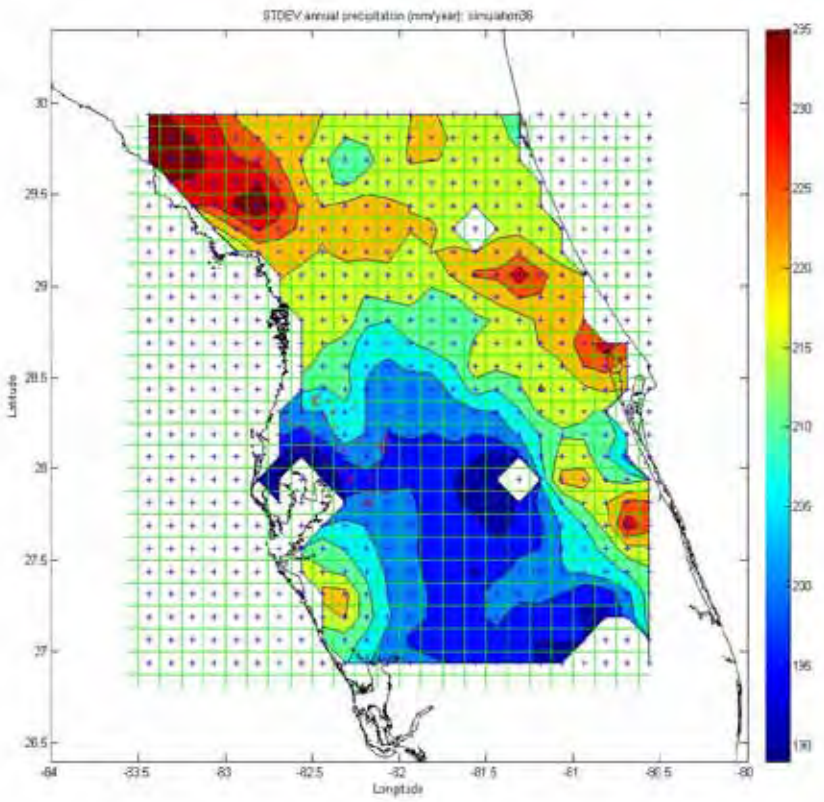
Gridded observation

190~300 mm

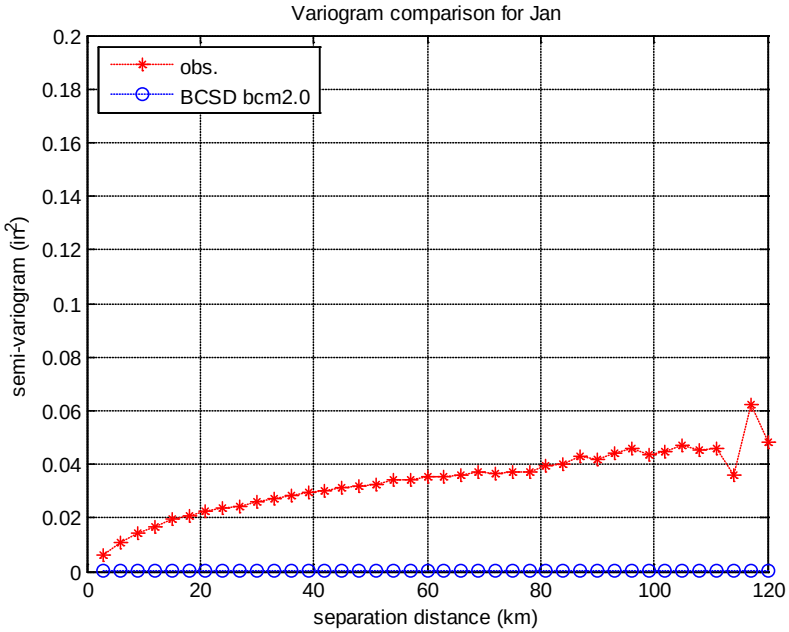


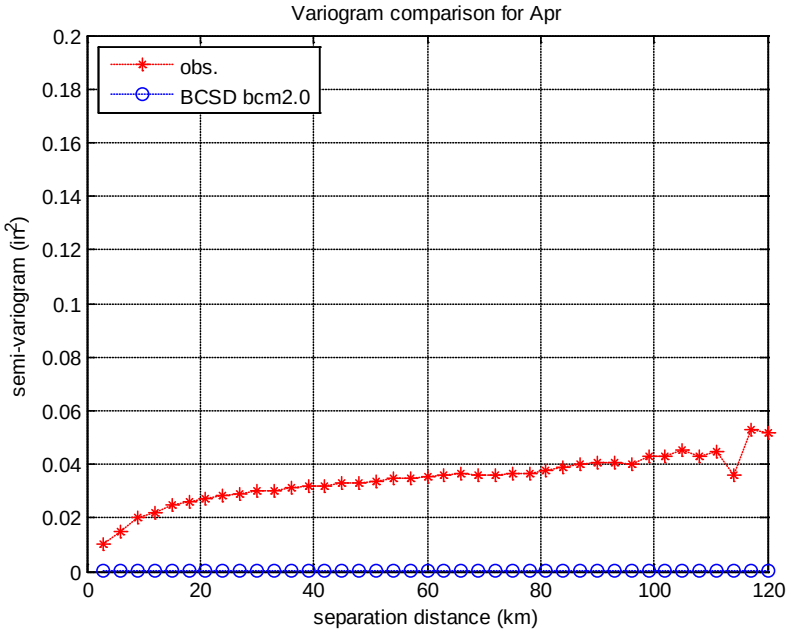
BCSD CMIP3 BCM2.0

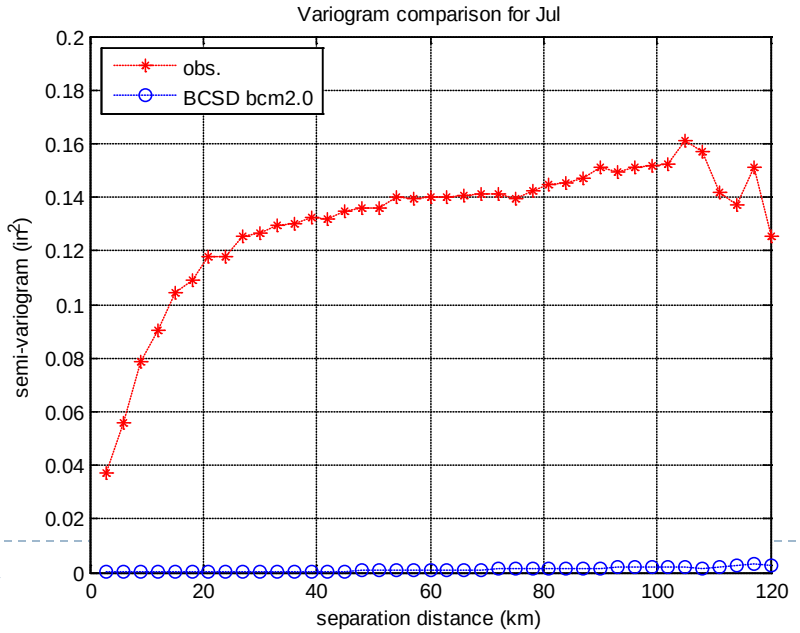
190~230 mm

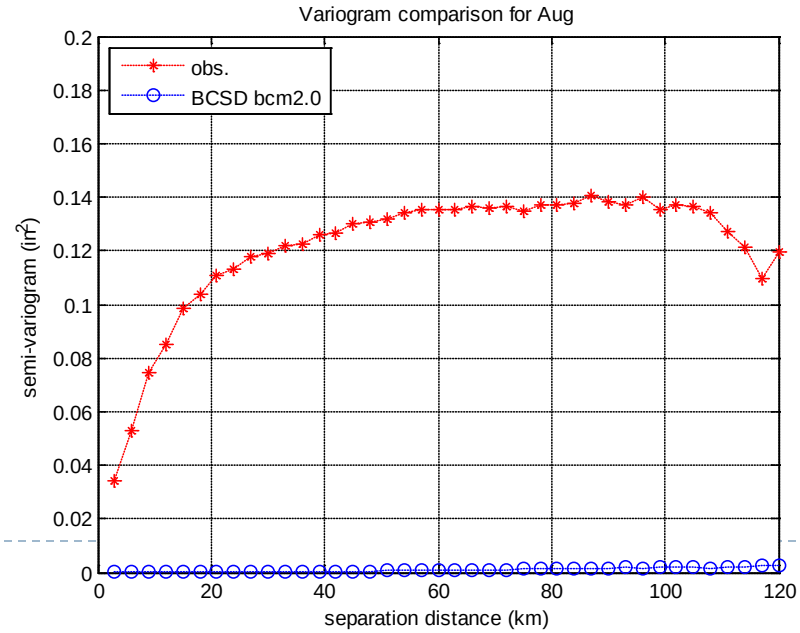


Variogram Comparison (obs. vs. BCSD bcm2.0)



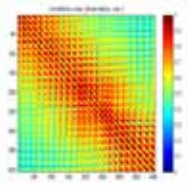


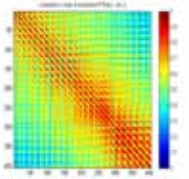


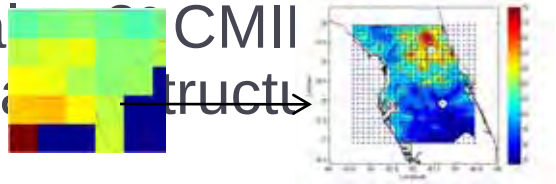


Alternative: Spatially Correlated Disaggregation

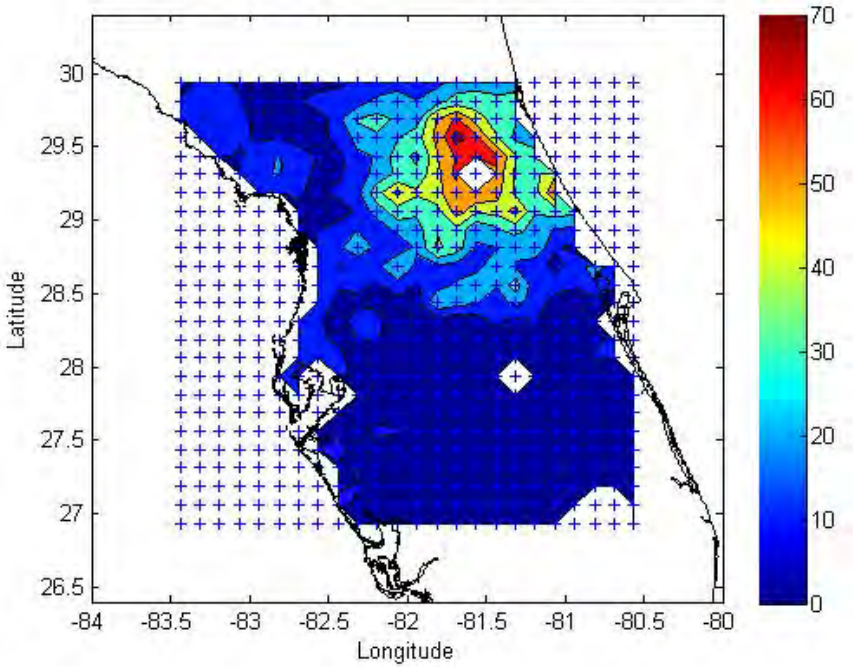
- New spatial disaggregation technique developed to improve small-scale spatial correlation structure of rainfall
  - Take normal score transform of observed daily precipitation data at each station
  - Estimate spatial covariance of normal score transform data over all stations
  - Use LU decomposition 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



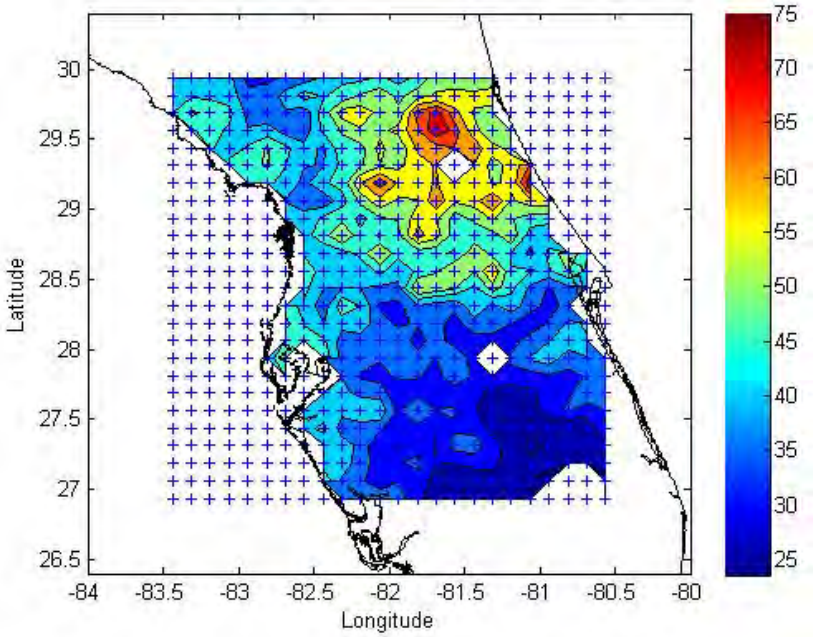




Example of spatial distribution

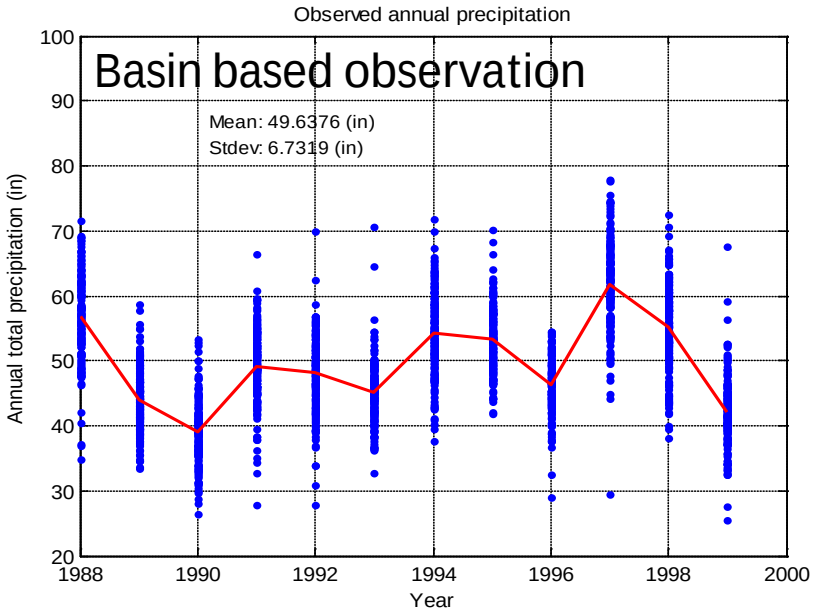


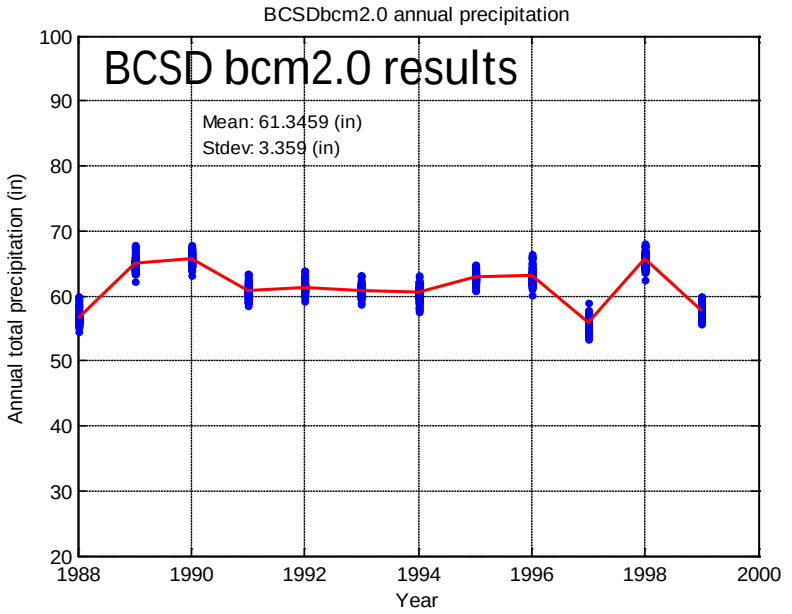
Spatial distribution of **BCSD CMIP3** rainfall field

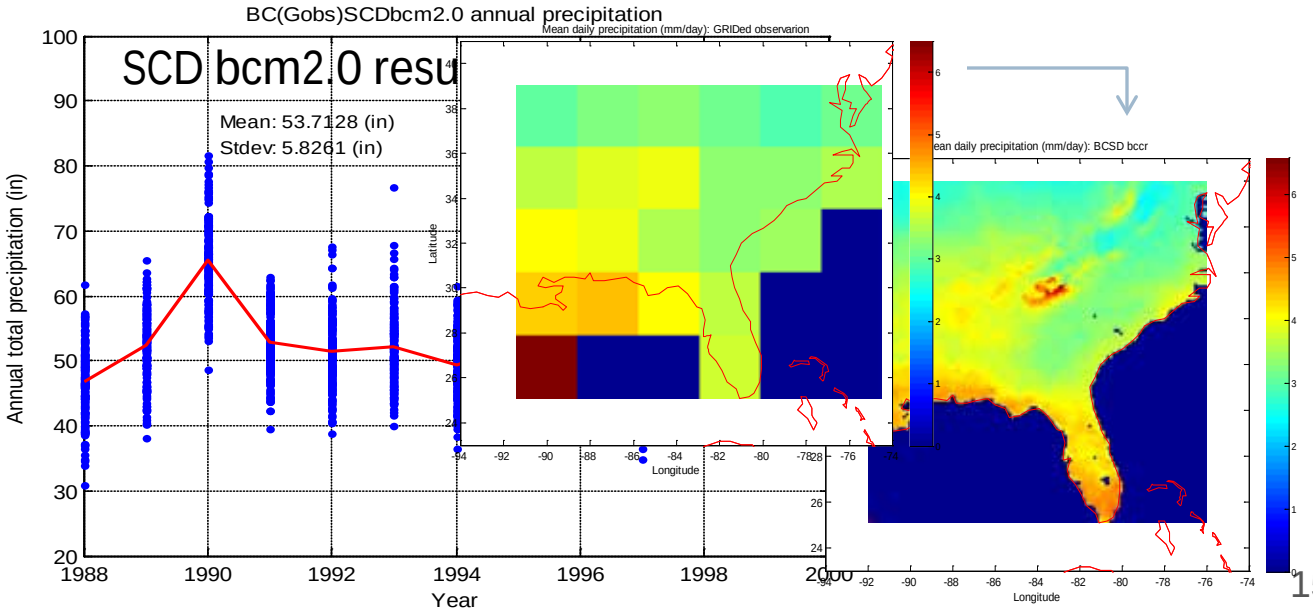


Spatial distribution of CMIP3 rainfall field disaggregated with **SCD** method

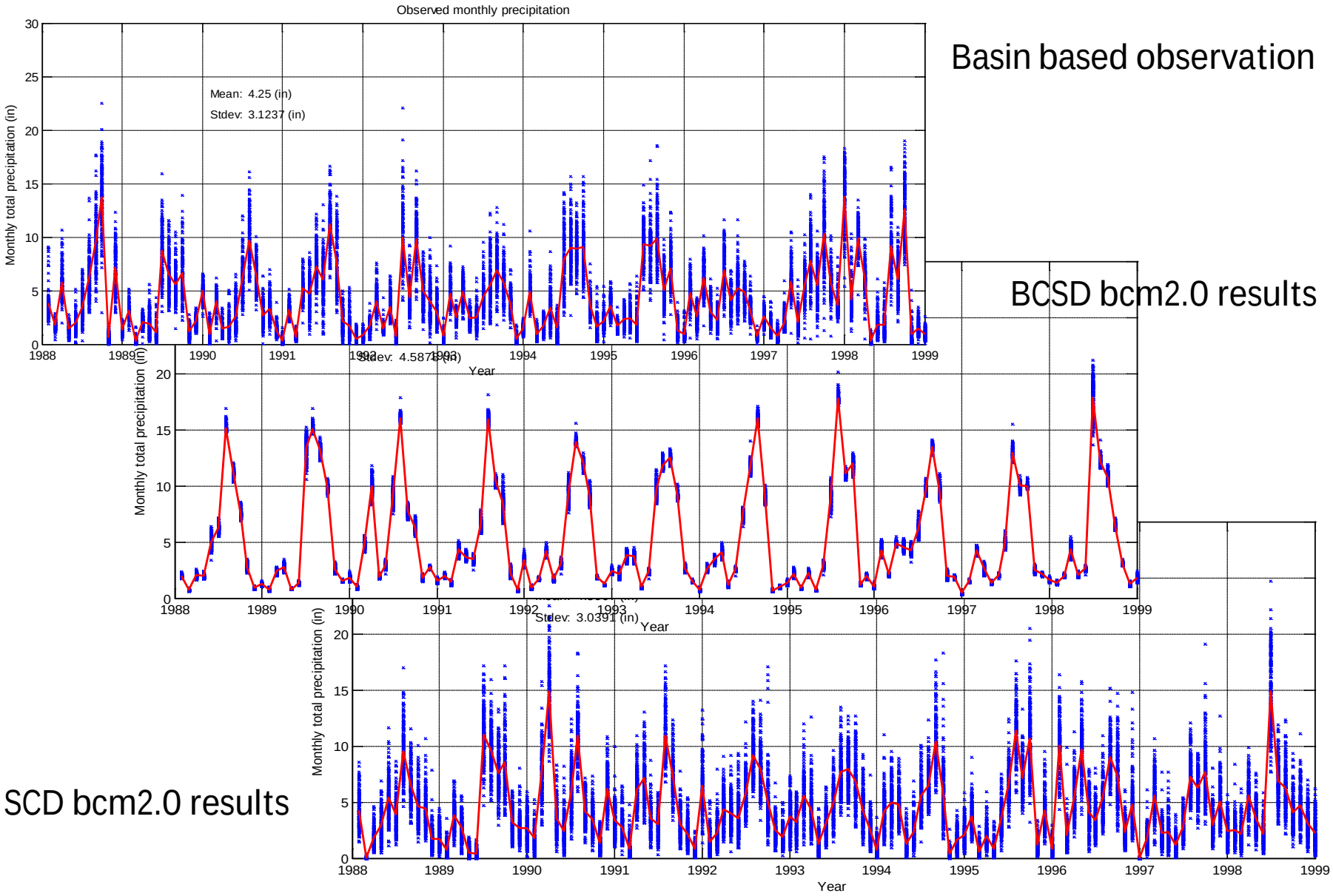
Annual precipitation comparison







Monthly precipitation comparison

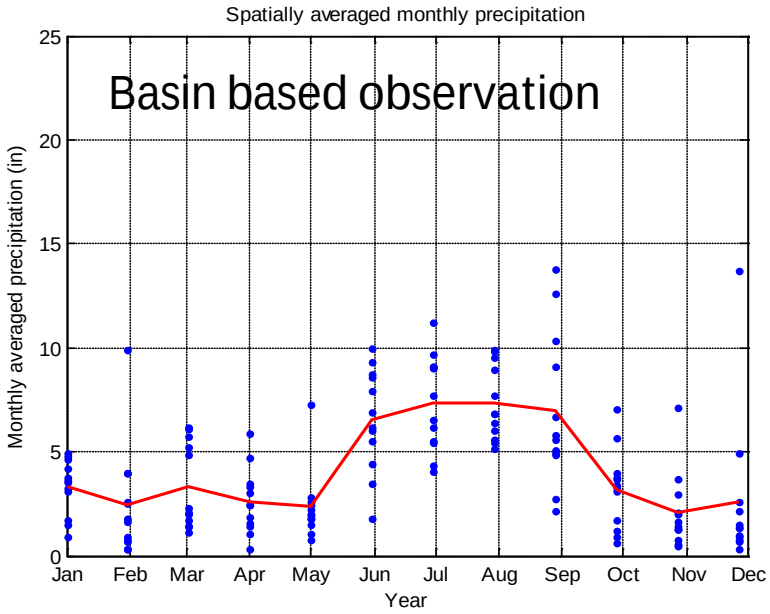


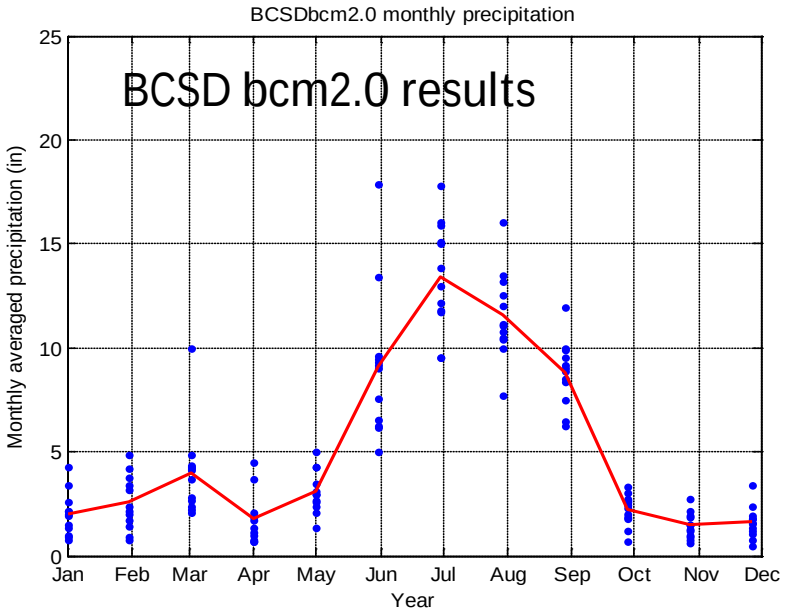
Basin based observation

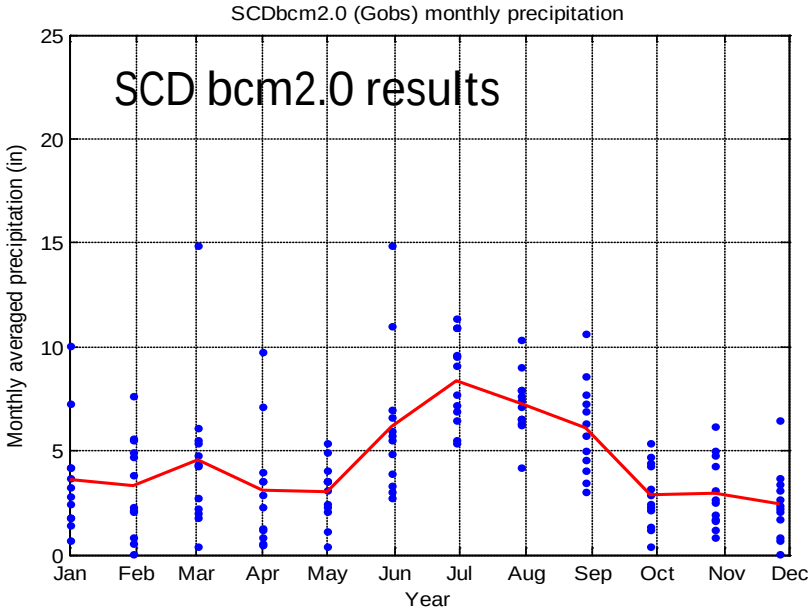
BCSD bcm2.0 results

SCD bcm2.0 results

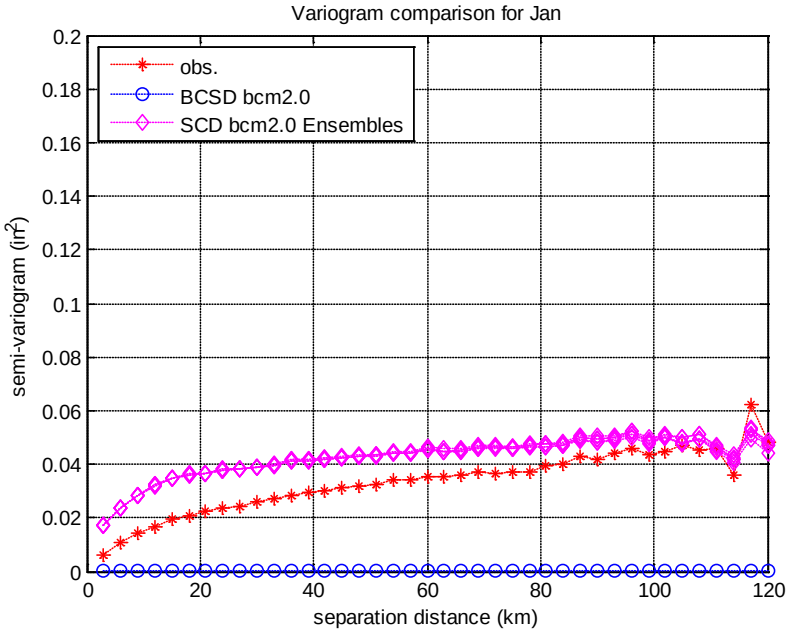
Monthly mean precipitation

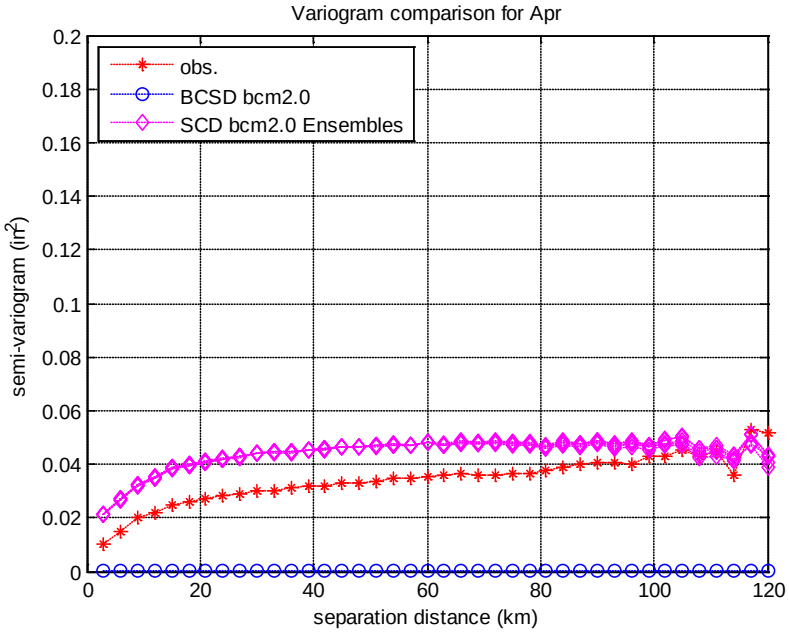


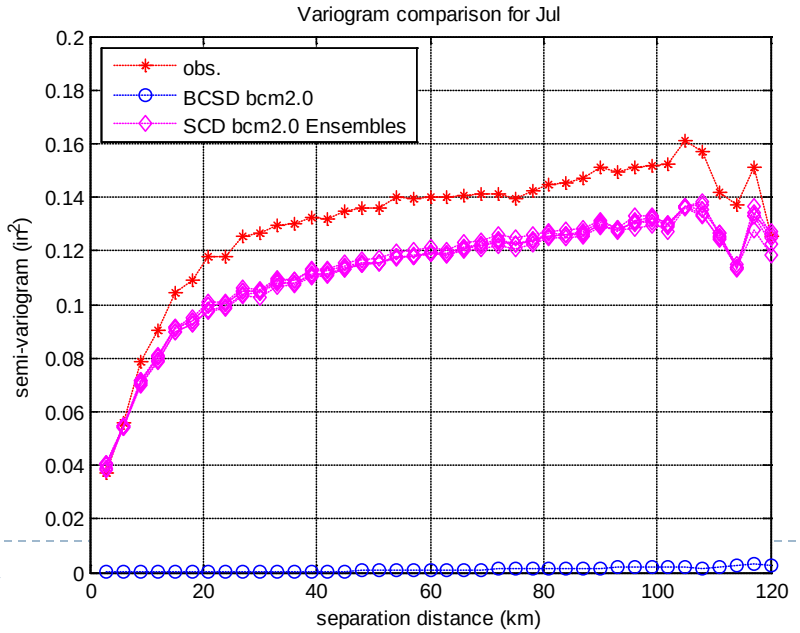


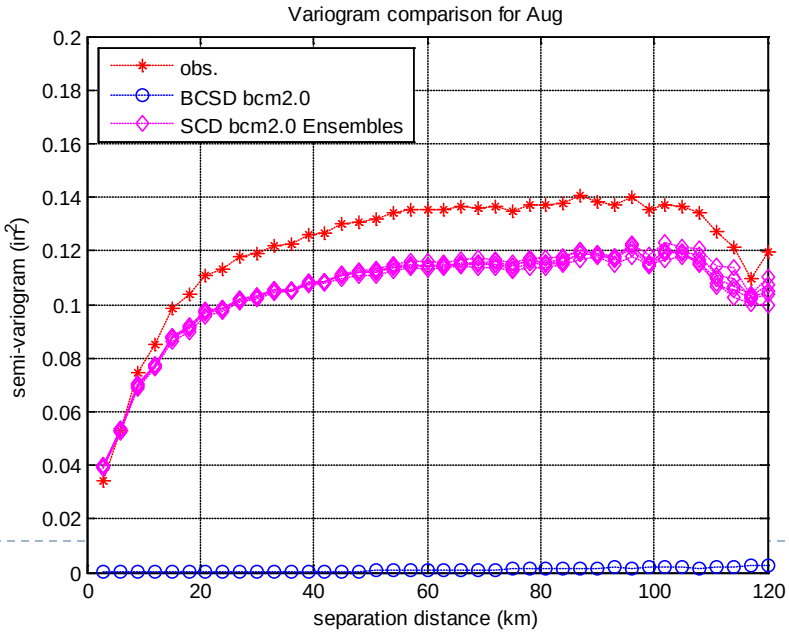


Variogram Comparison (obs. vs. BCSD vs. SCD bcm2.0)









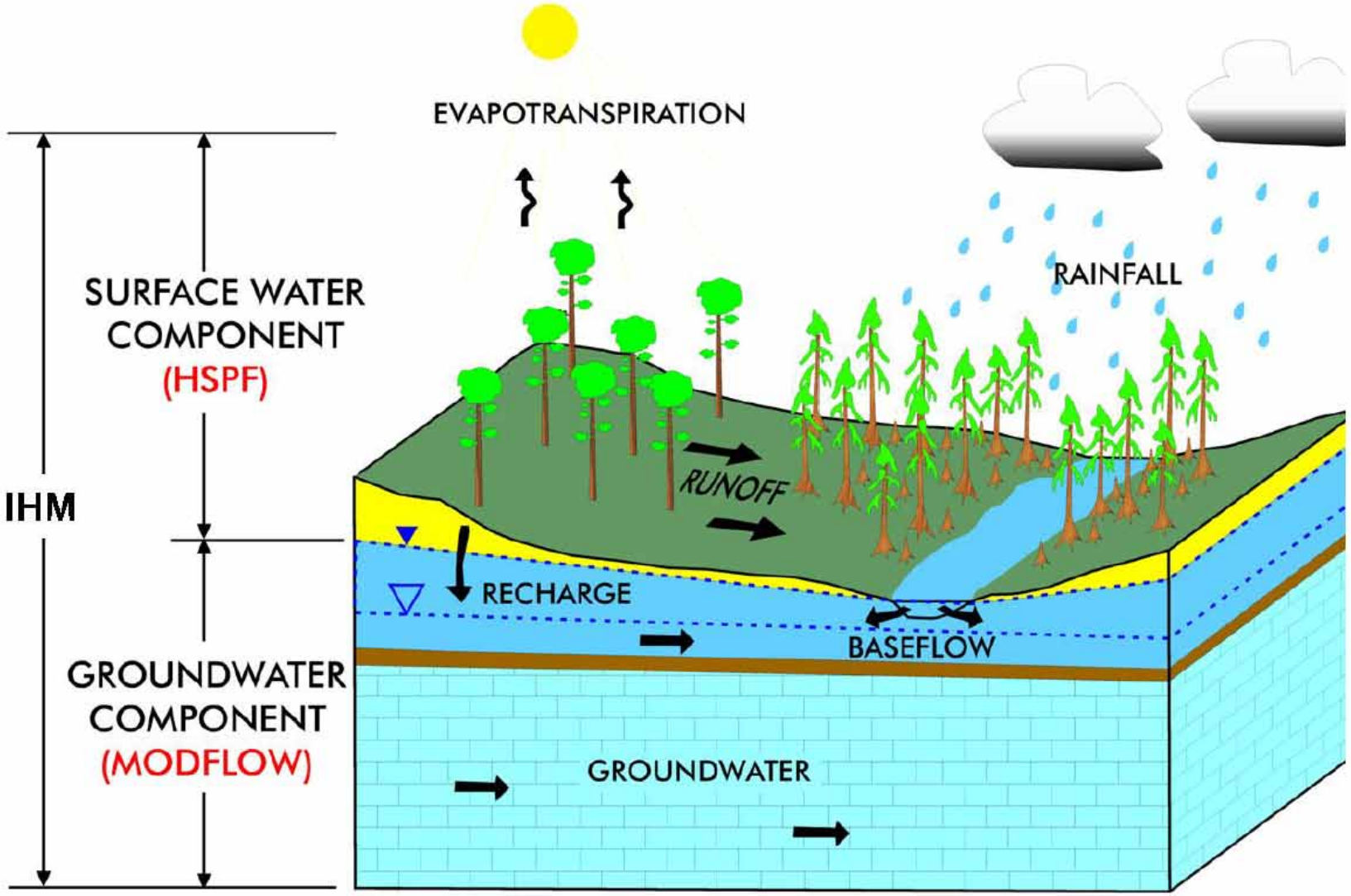
Summary of precipitation analysis for BCM2.0

- 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)

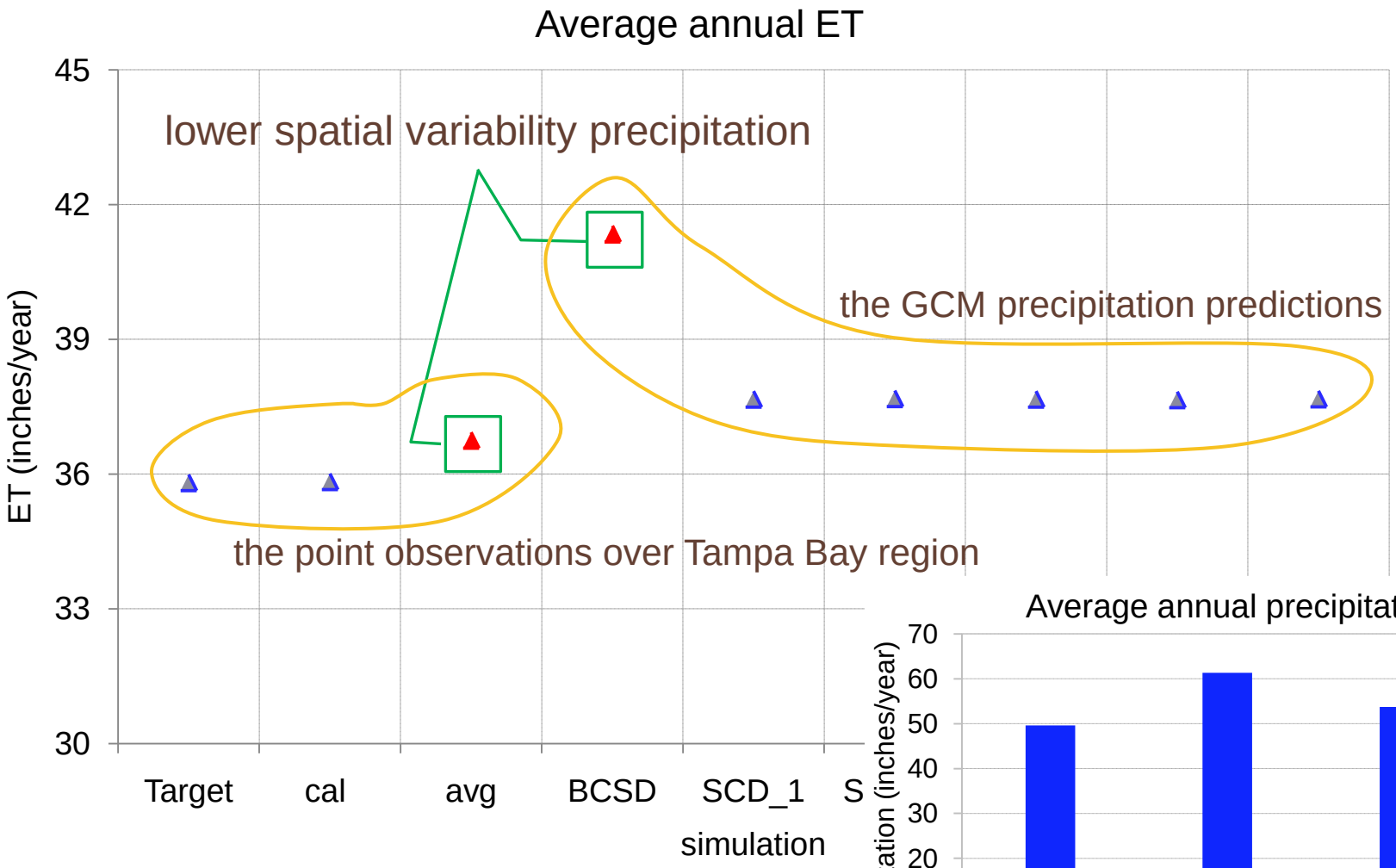
- Evaluate the ability of bias-corrected and spatially-disaggregated GCM retrospective simulations (CMIP3) to reproduce observed hydrologic behavior using IHM

- 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.

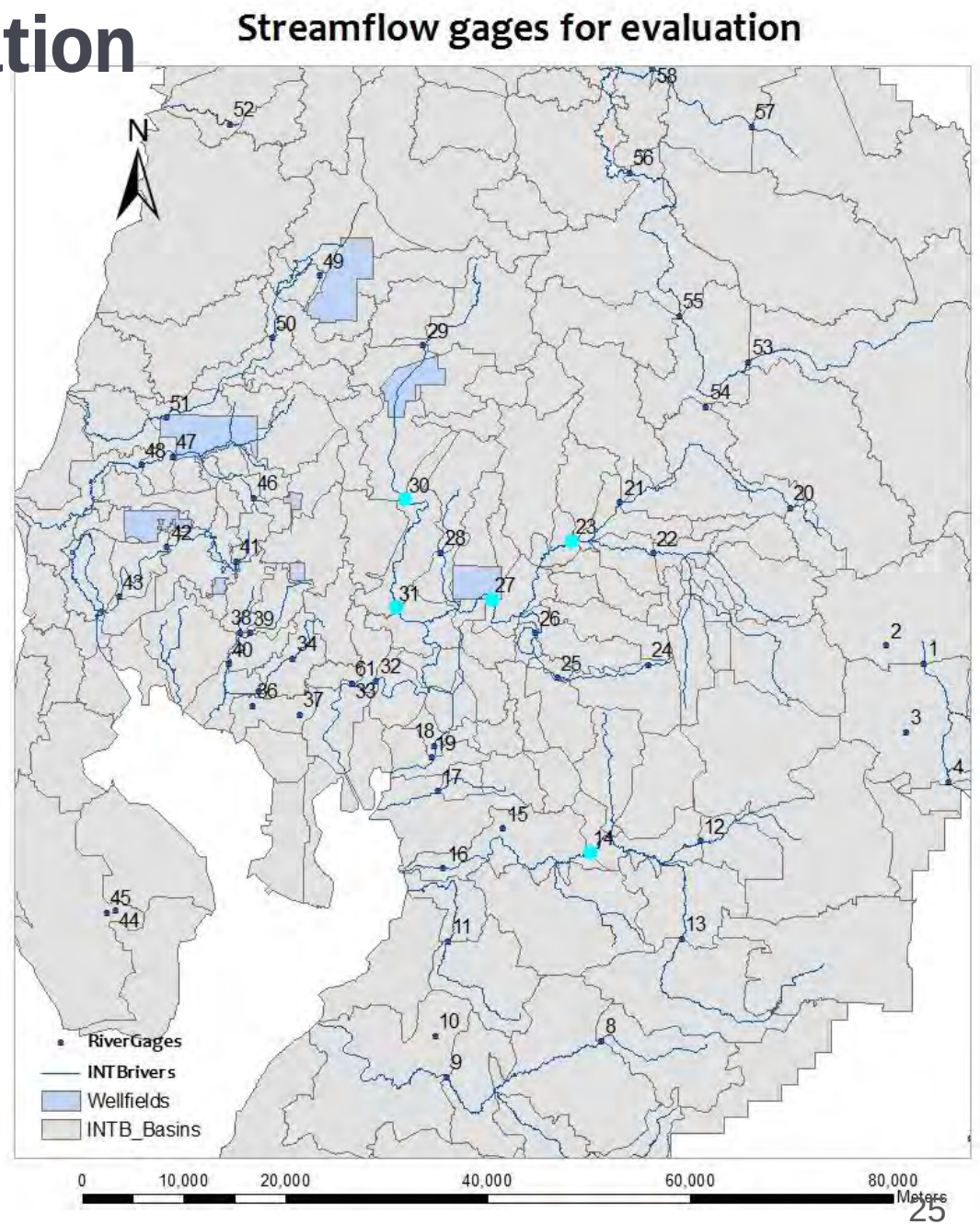
Simulated average annual Rainfall & ET over the domain



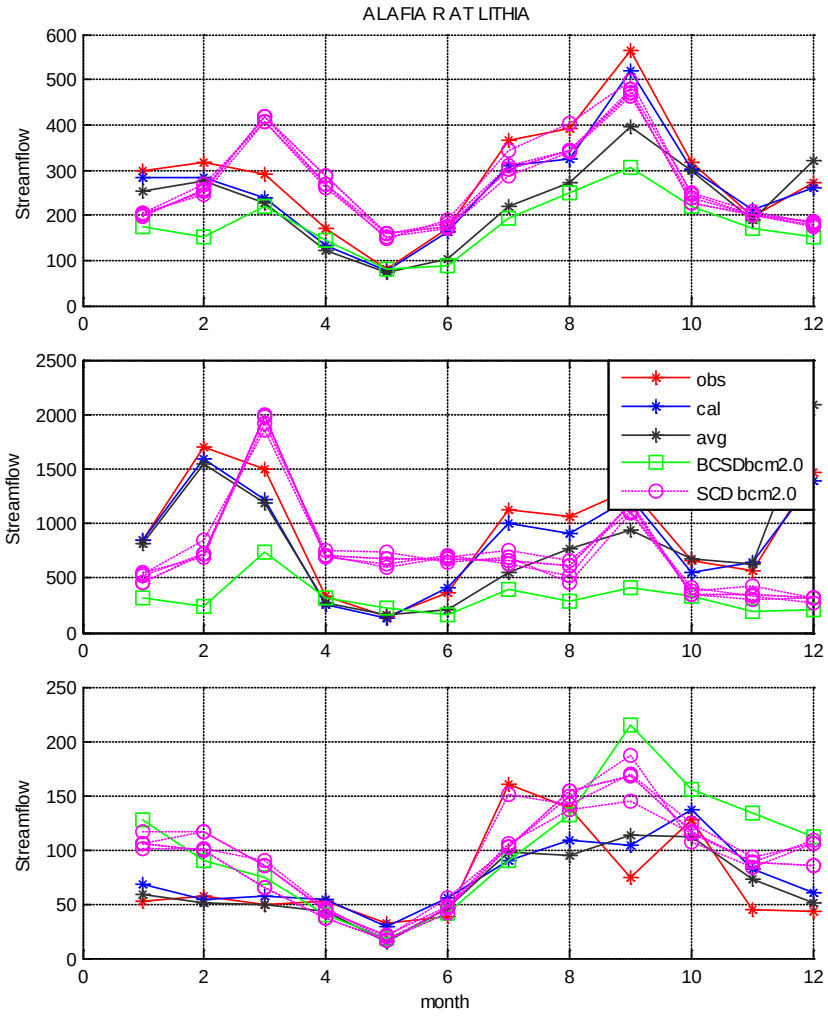
1. Streamflow evaluation

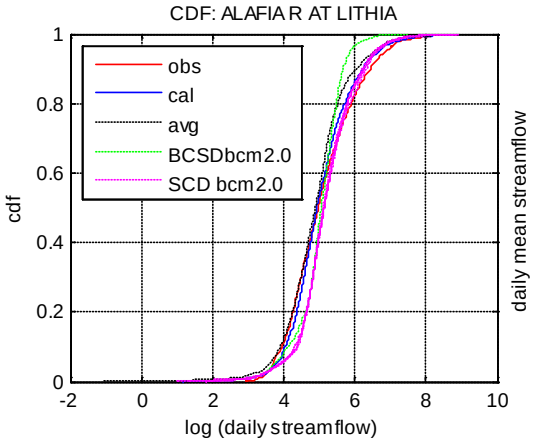
- Target stations

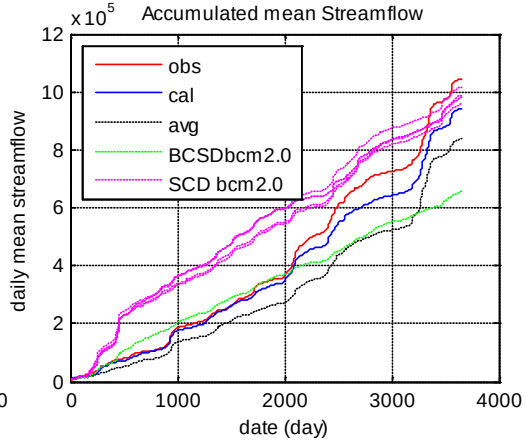
1. Alafia at Lithia (14)
2. Cypress Creek at Worthington (30)
3. Cypress Creek near Sulfur spring (31)
4. Hillsborough river at Morris Bridge (27)
5. Hillsborough river at Zephyrhills (23)
6. Anclote river near Elfers
7. Anclote river near Odessa

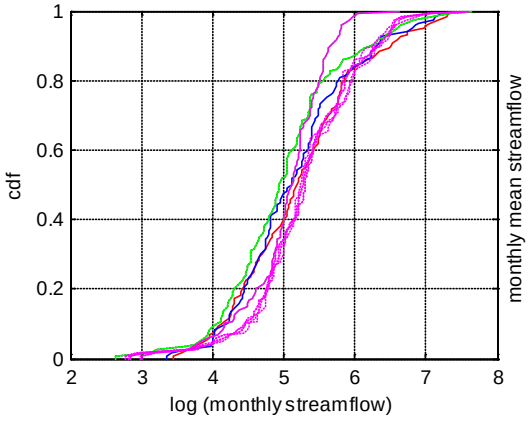


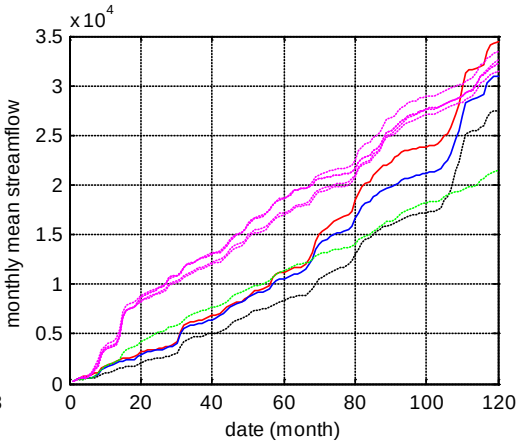
Results for Alafia at Lithia







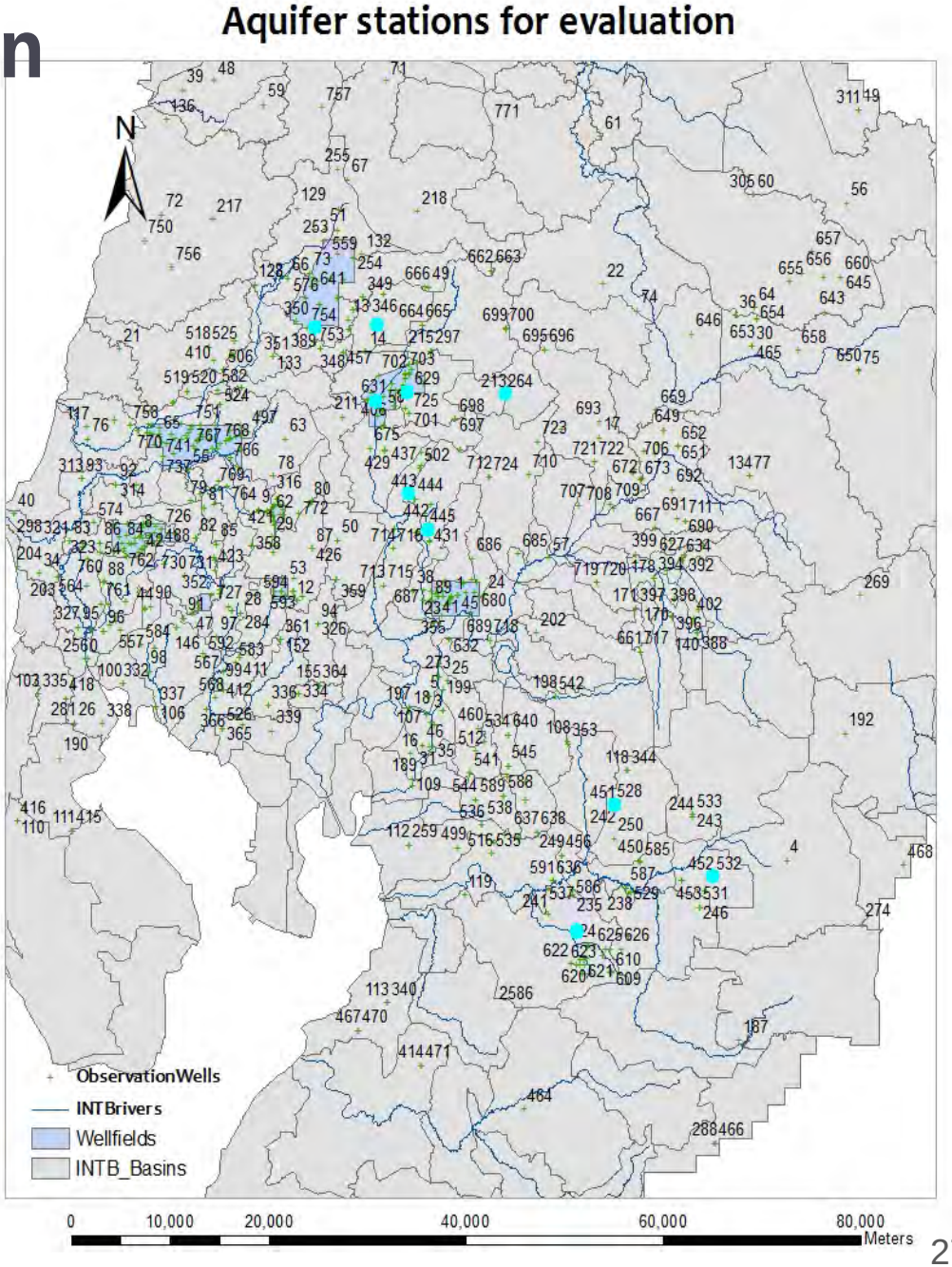




2. Aquifer evaluation

- Target stations

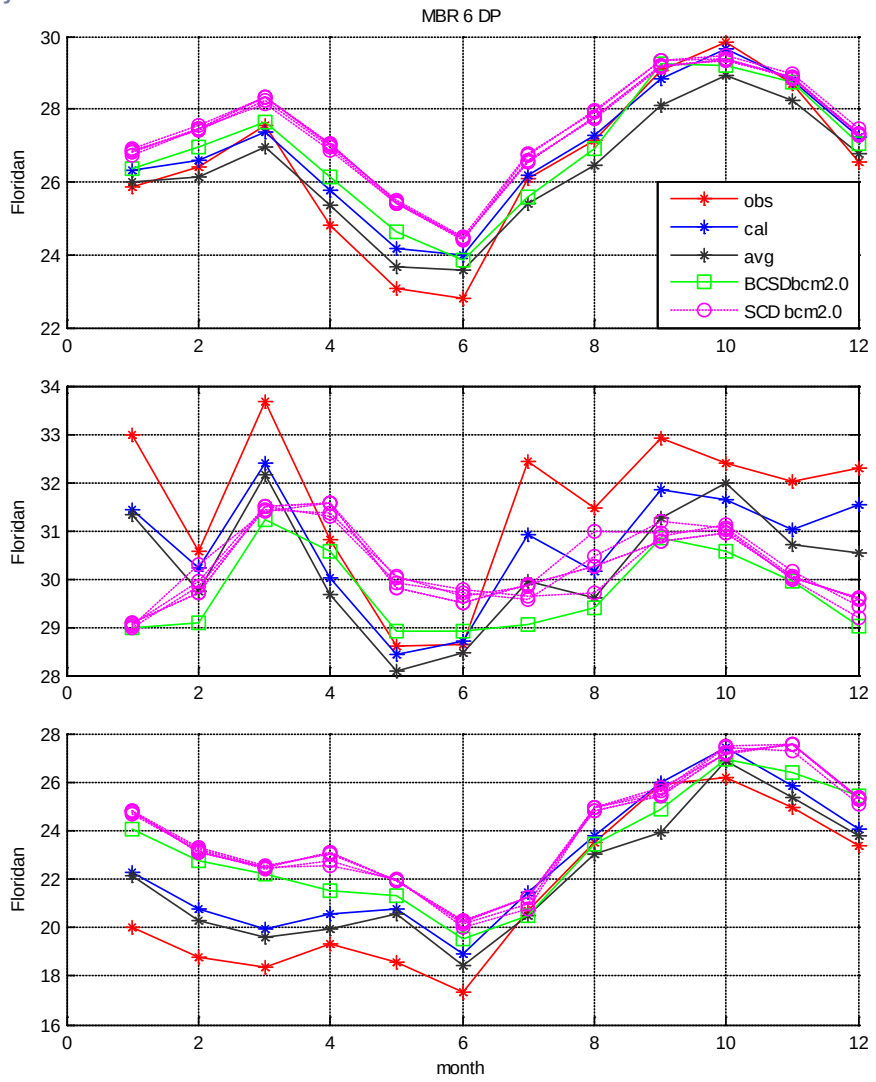
13 pairs of groundwater level stations for Floridan and Surfical aquifer are selected to evaluate the results



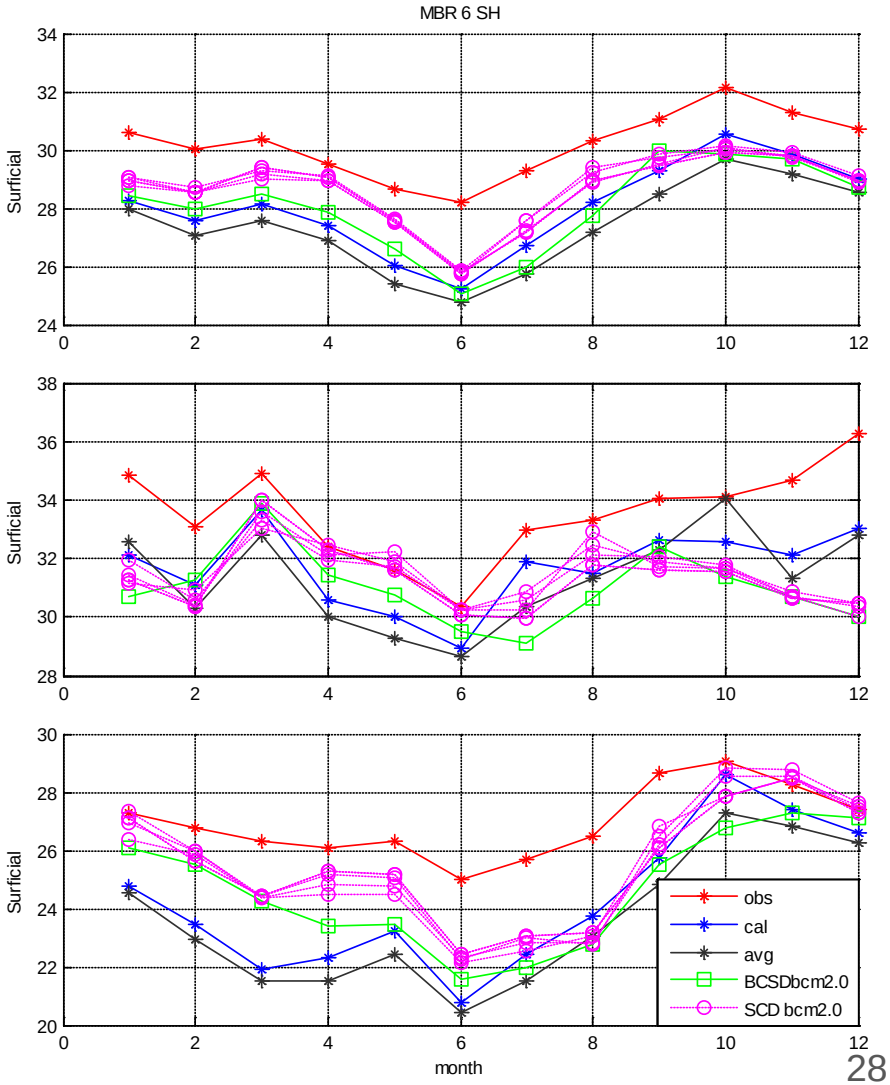
Comparison of the mean, maximum, and minimum monthly averaged groundwater level for each month

Seasonal groundwater level

1. Floridan



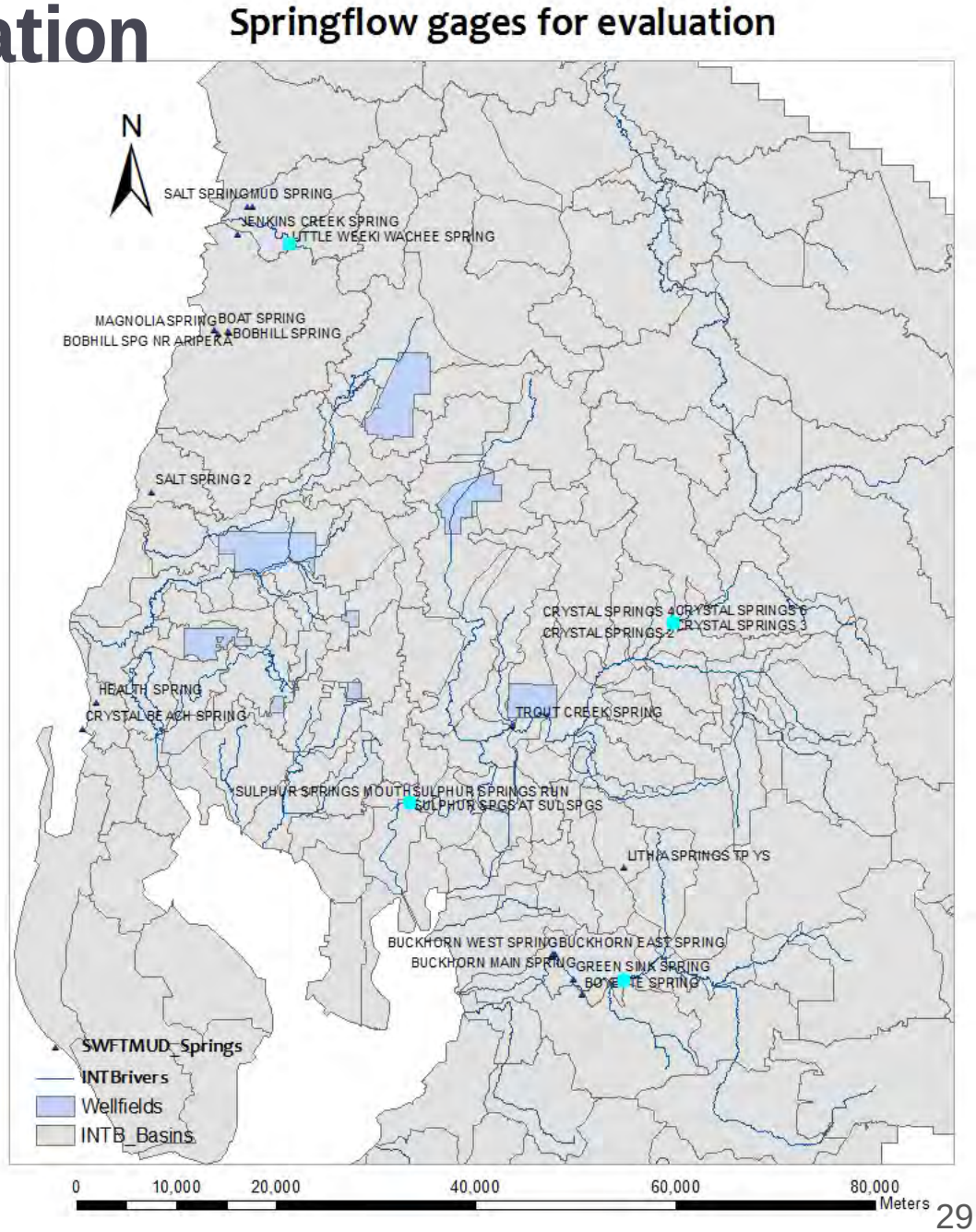
2. Surficial



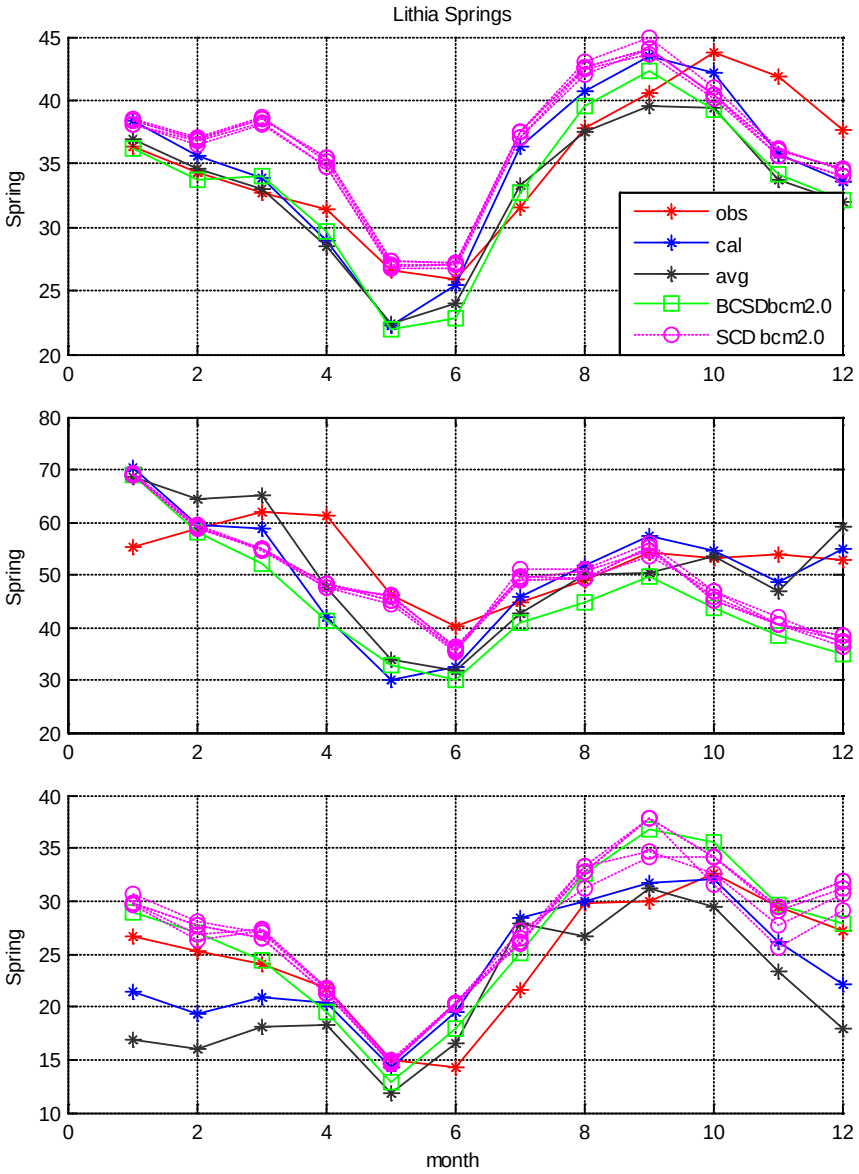
3. Springflow evaluation

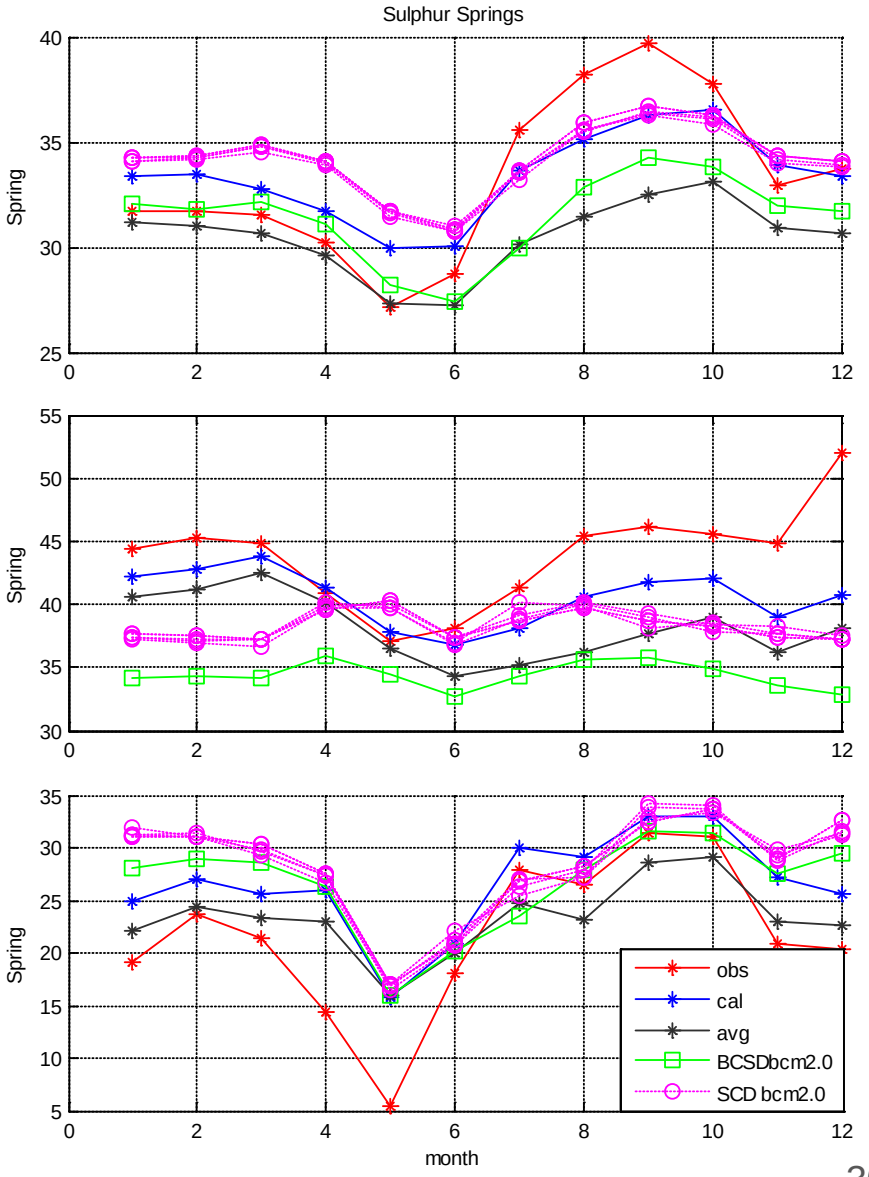
- Target stations

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?