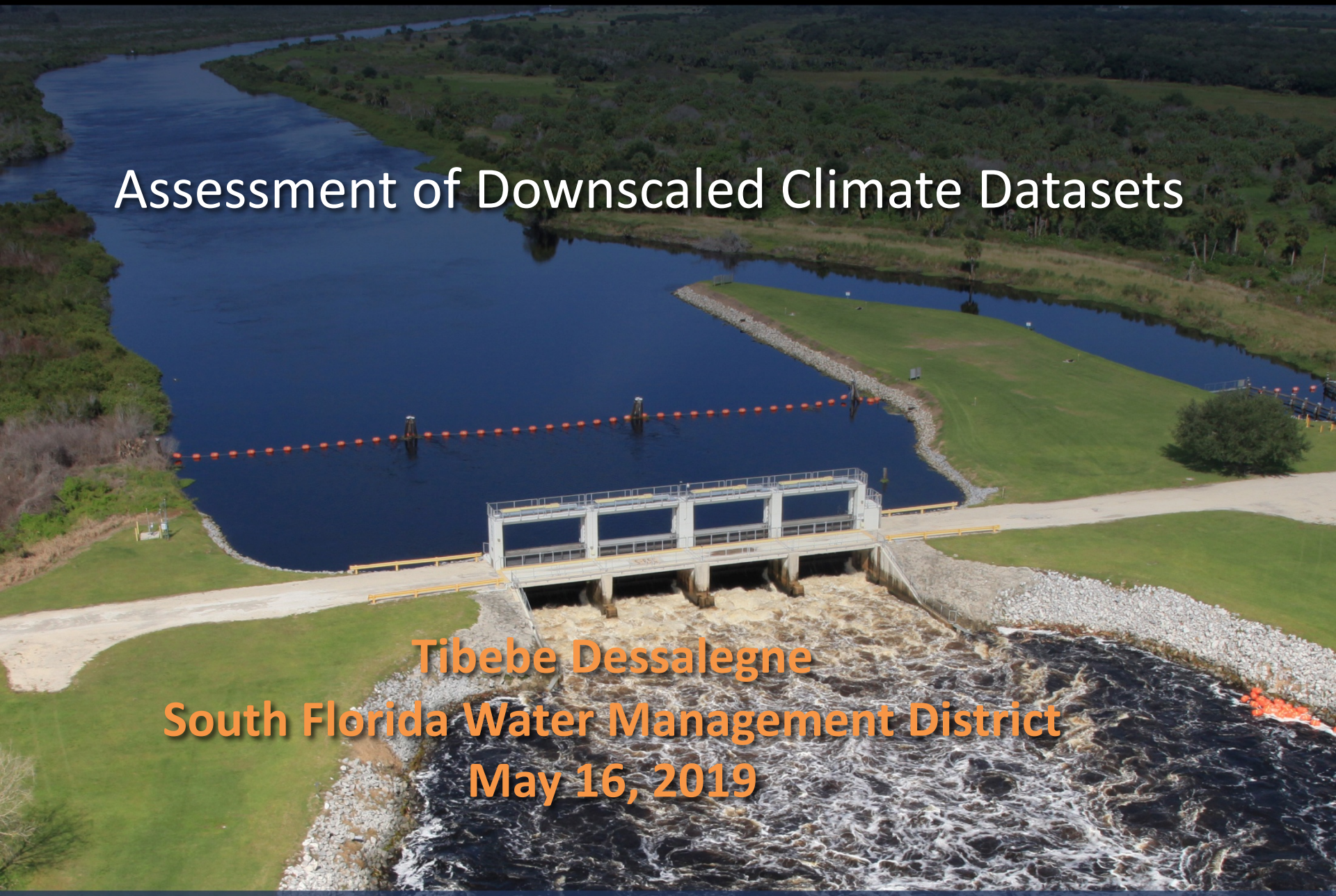
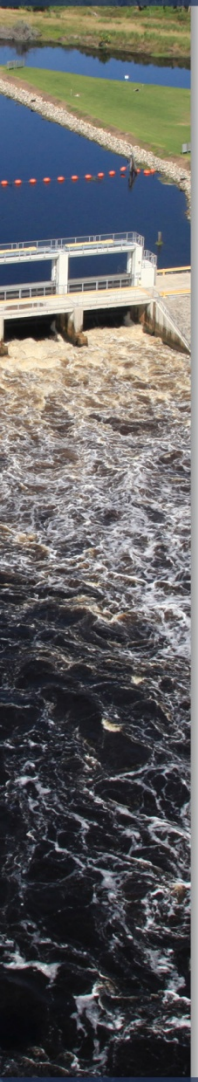
Assessment of Downscaled Climate Datasets



Tibebe Dessalegne
South Florida Water Management District
May 16, 2019

Collaborators

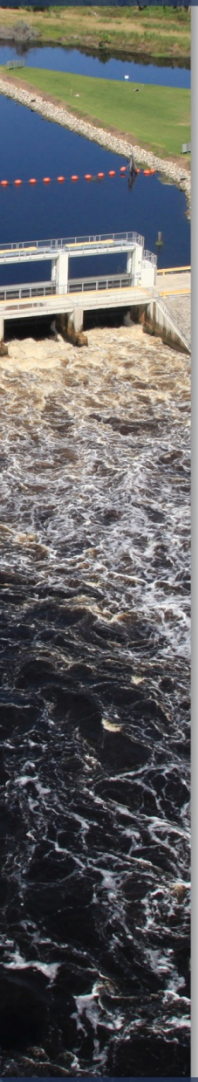


- Jayantha Obeysekera (Former SFWMD)
- Michelle Irizarry (Former SFWMD)
- Sashi Nair
- Jenifer Barnes
- Luis Cadavid
- Ken Konyha

Project Oversight:

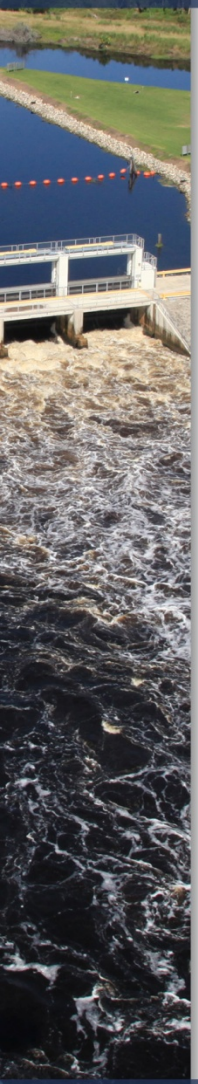
- Matahel Ansar
- Walter Wilcox
- Akin Owosina

Outline



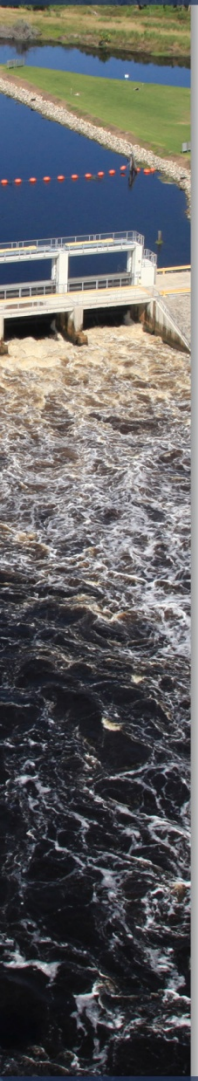
- Background – South Florida Water Management System
- Global Climate Dataset – CMIP3/CMIP5
- Climate Data Analysis
- Future Regional Water Resources Assessment
- Summary & Conclusion

Background

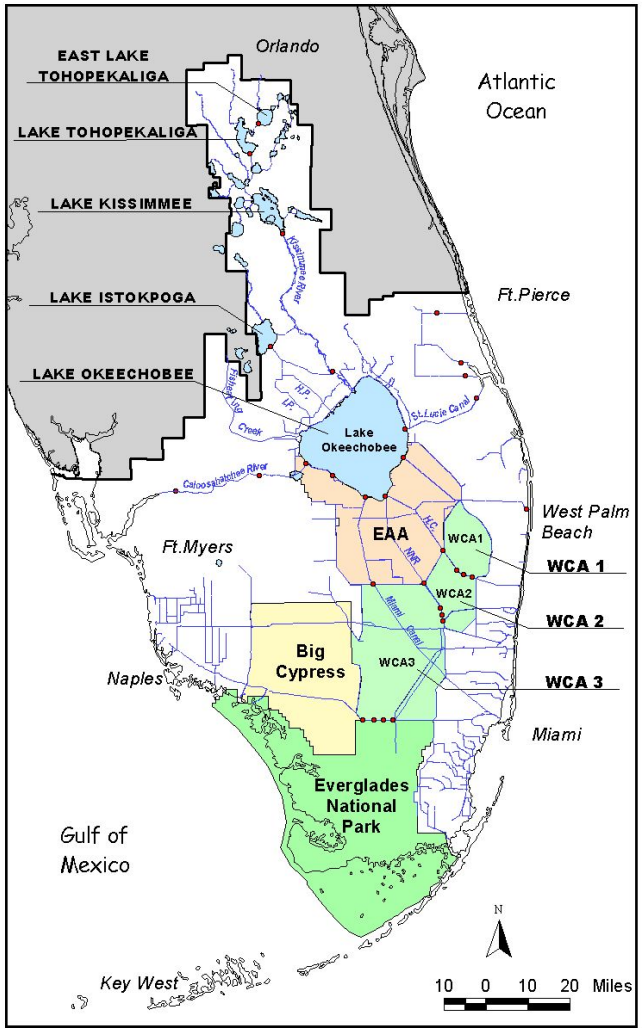


To safeguard and restore South Florida's water resources and ecosystems, protect our communities from flooding, and meet the region's water needs while connecting with the public and stakeholders.

Background



- South Florida Water Management System
  - Low relief & flat topography
  - Delicate balance between rainfall and evapotranspiration
  - High ground and surface water interaction
  - Urbanized areas along the coast
  - Significant agricultural areas
  - Protected natural areas such as the Everglades
  - Lake Okeechobee
  - 2,100 miles of canals, 2,000 miles of levees/berms, 700+ water control structures, 70+ pump stations and 625 project culverts



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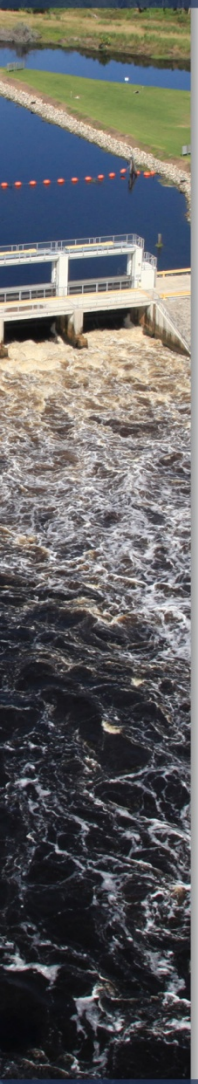
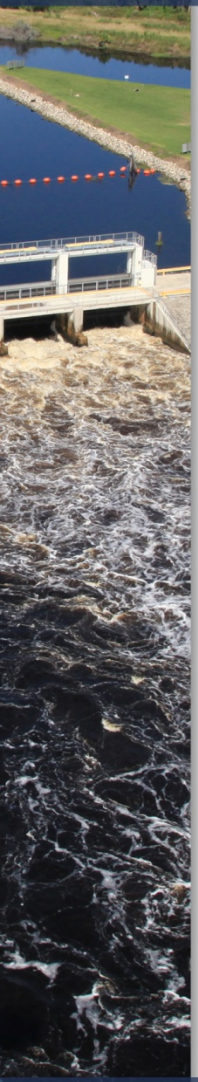
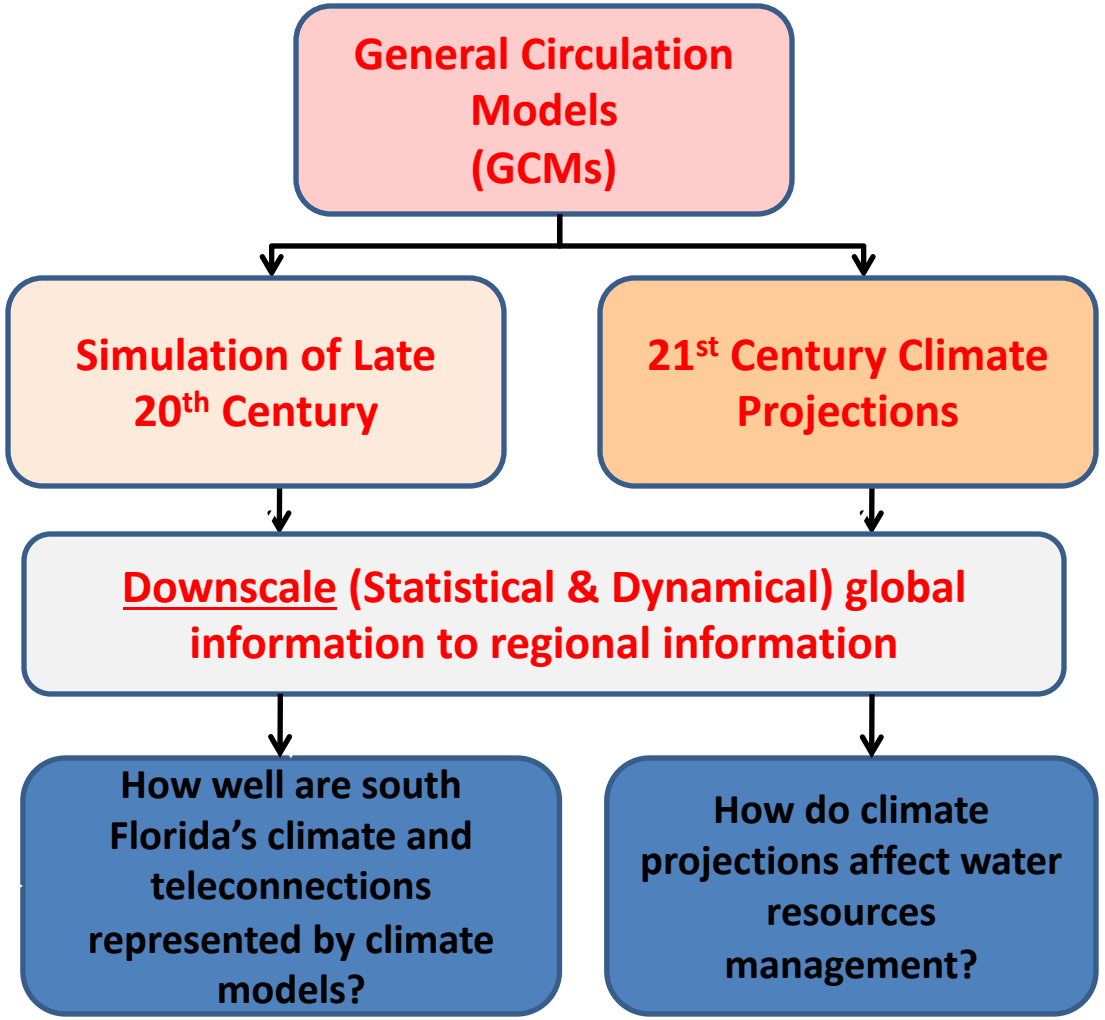


- SFWMD Uses two major types of climatic data:
  - Long duration (41 years), spatially distributed (2 mi x 2mi grid) daily rainfall and reference ET
  - Extreme event (i.e. design storm) 15-minute rainfall time-series

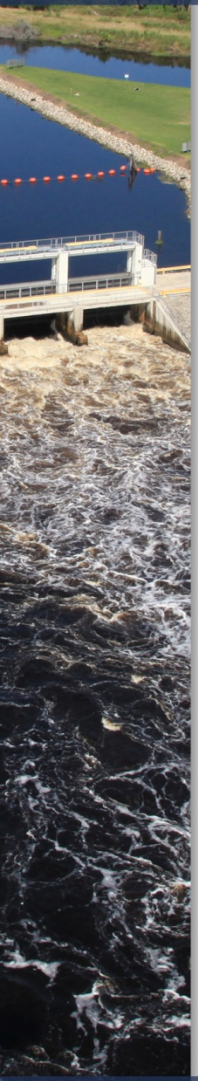
Global Climate Dataset - GCM



- General circulation models (GCMs) play an important role in projecting future water condition of a region

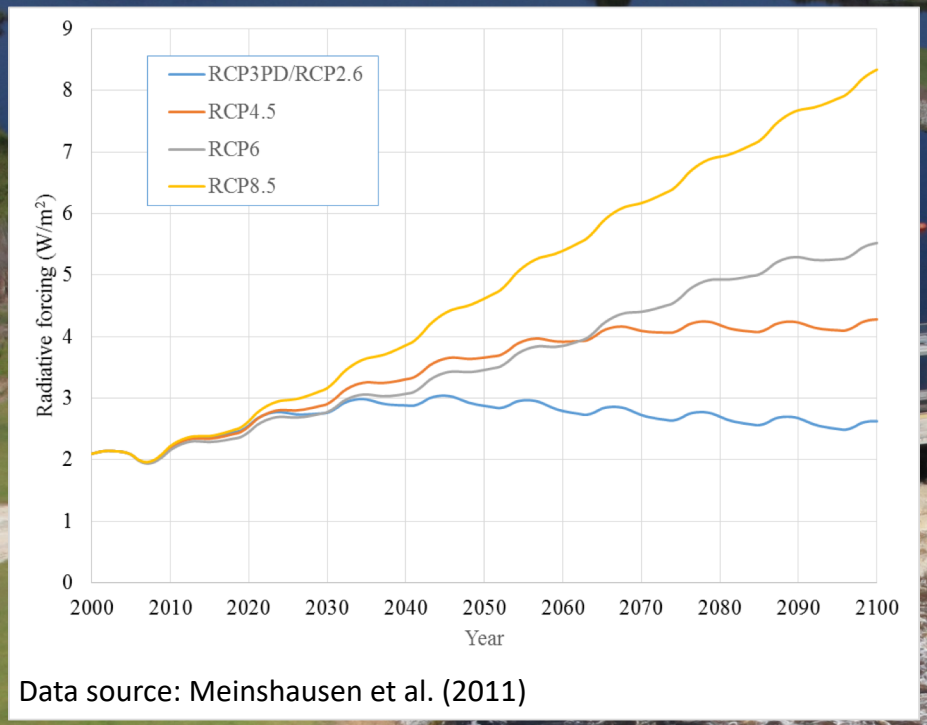


Downscaling CMIP3 & CMIP5 GCM Climate Projections

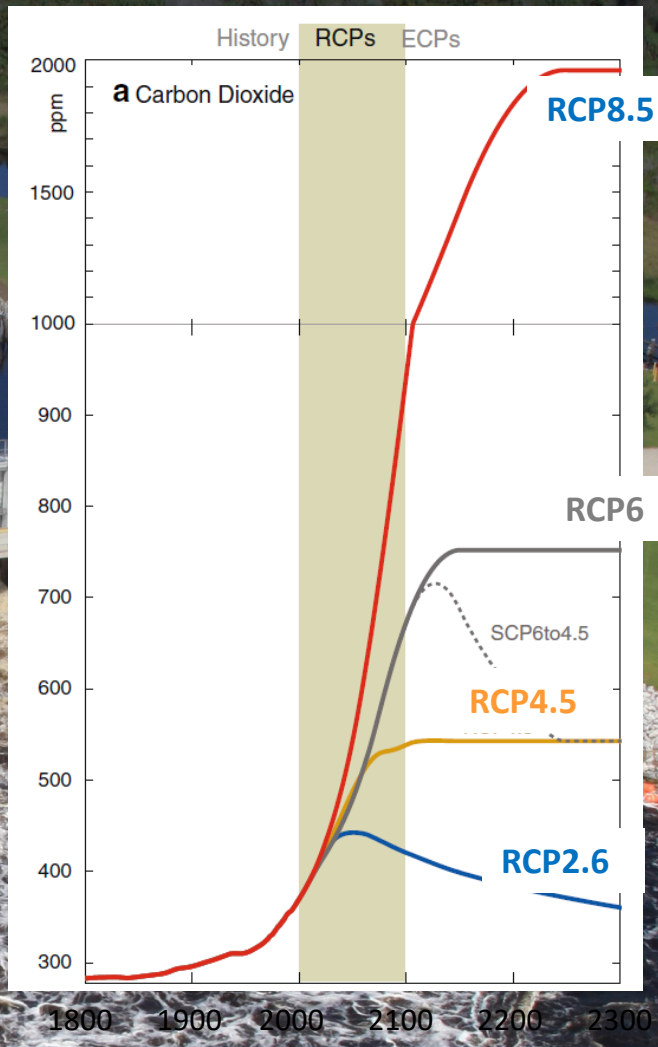


- **Statistical Downscaling** (~12 km)
  - BCSD (Bias-Corrected, Spatially-Downscaled)
  - BCCA (Bias-Corrected, Constructed Analogs)
  - SOM method: Penn State (FIU-WCS project)
  - LOCA (Localized Constructed Analogs) - analysis ongoing
- **Dynamical Downscaling** (using Regional Climate Models)
  - NARCCAP (from NCAR) (~50km)
  - FSU – Regional Spectral Model (~10km)
  - WCRP CORDEX (not analyzed yet)

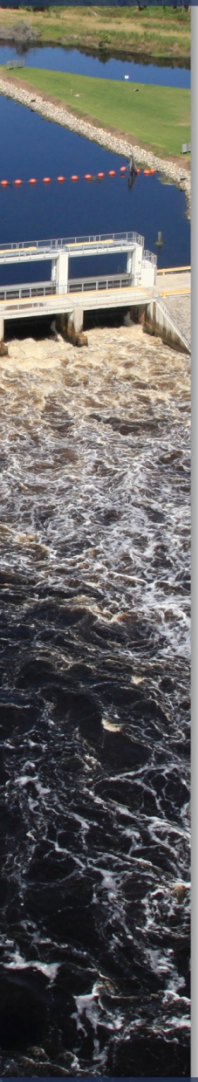
Global Climate Dataset – CMIP5 - RCPs



Data source: Meinshausen et al. (2011)

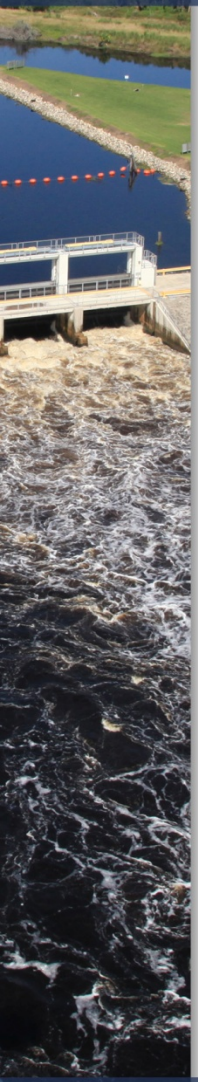


Global Climate Dataset – CMIP5



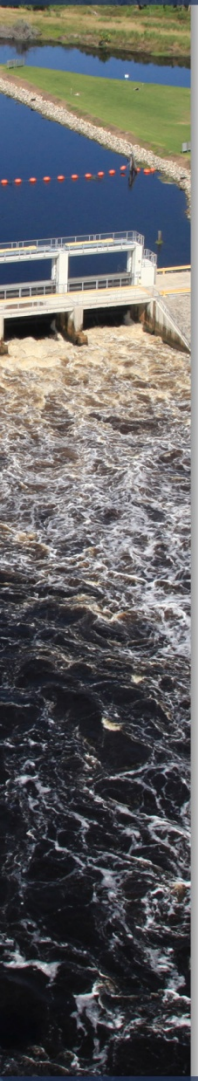
- Precipitation and minimum and maximum air temperature downscaled statistically over contiguous U.S:
  - Monthly bias-correction and spatial disaggregation (BCSD) and
  - Daily bias-correction and constructed analogs (BCCA)
- Spatial resolution is 1/8 degree x 1/8 degree (about 12 km x 12 km)

Climate Data Analysis

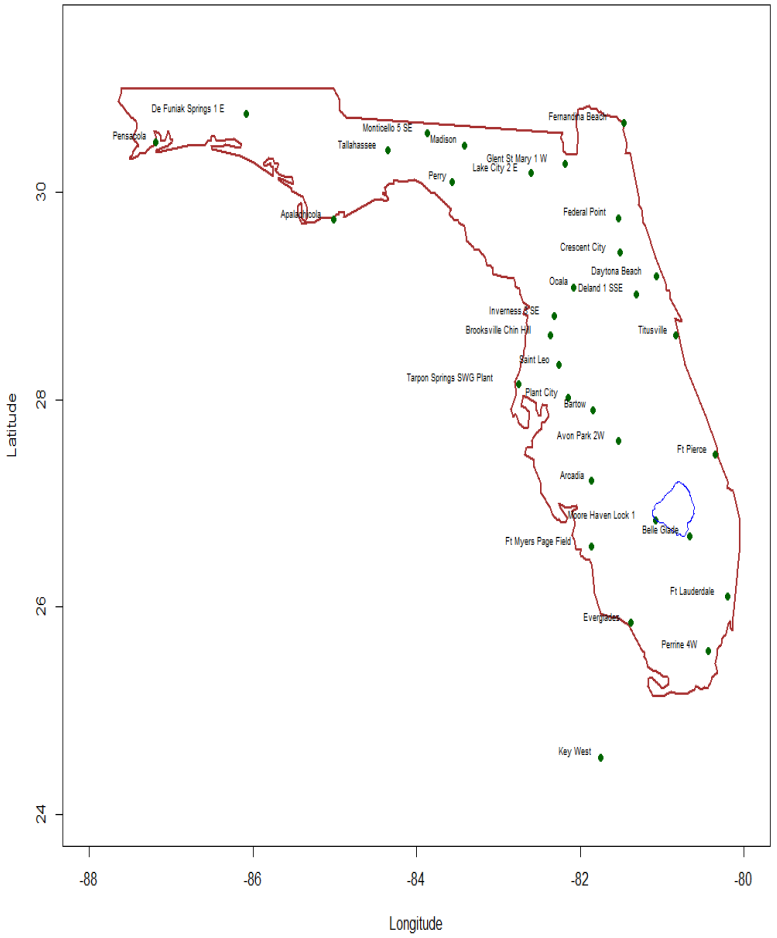


- Daily BCCA dataset was utilized for the analysis
- A total of 119 model outputs corresponding to RCP2.6 (36), RCP4.5 (42) and RCP8.5 (41) were used
- Analysis was conducted:
  - Point data at selected 32 gages in Florida
  - Regional data over SFWMM model domain
  - Three time periods: Base (1970-2000); Near Future (2025-2055) and Far Future (2055-2085)

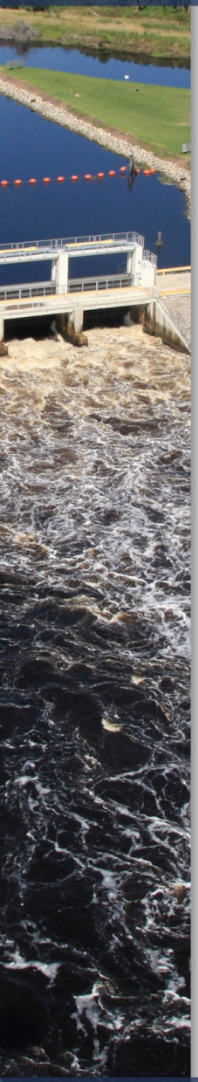
Climate Data Analysis – Point Data

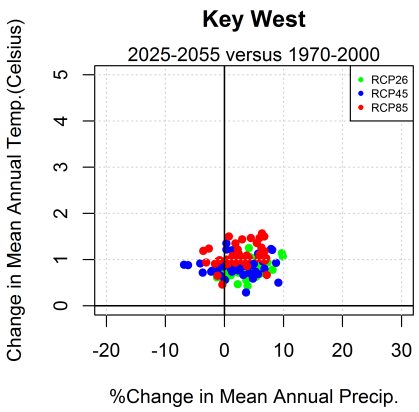


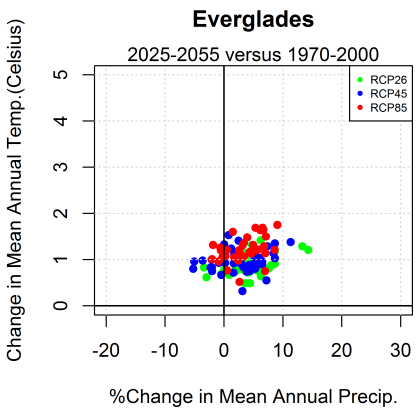
- 32 gages in Florida
- Percent change in average precipitation
- Change in average temperature
- Near future vs Base
- Far future vs Base

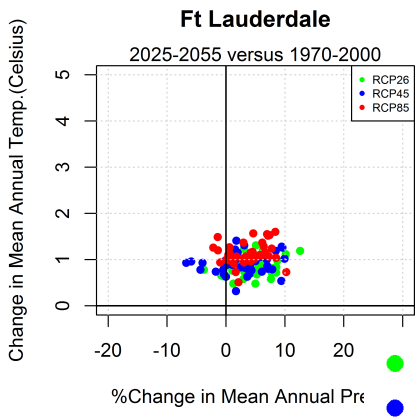


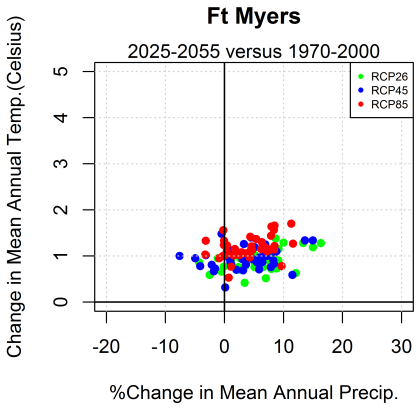
Climate Data Analysis – Point Data – Near Future

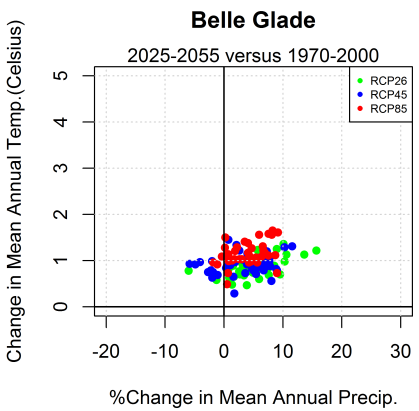


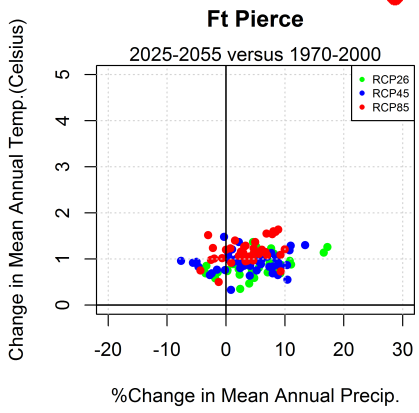






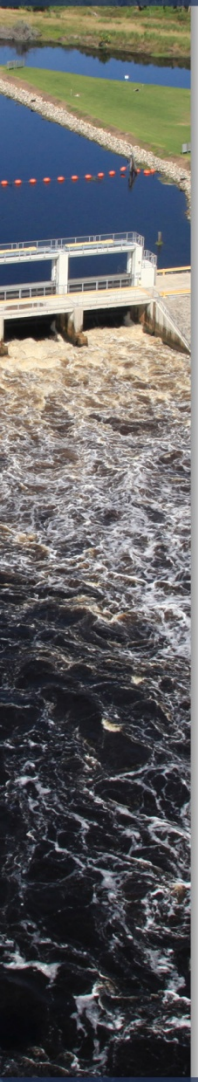


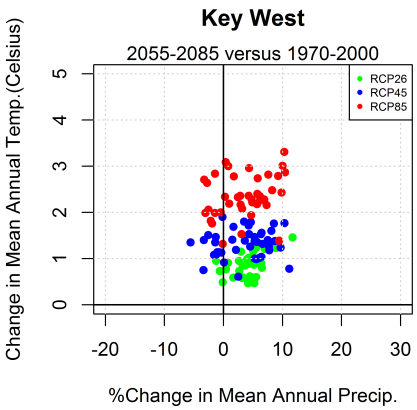


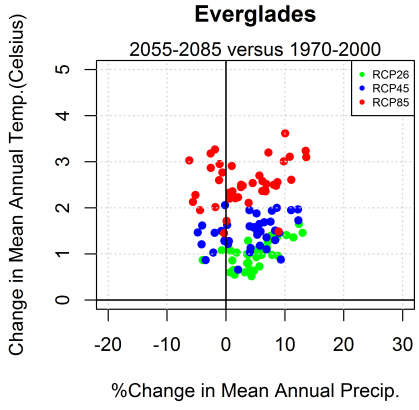


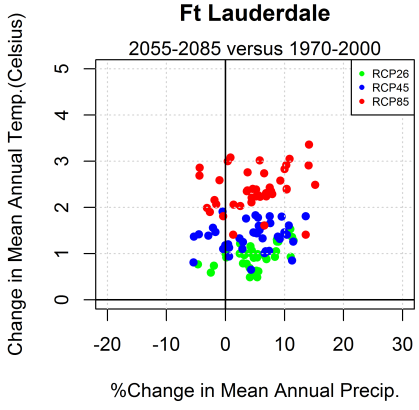
RCP26
RCP45
RCP85

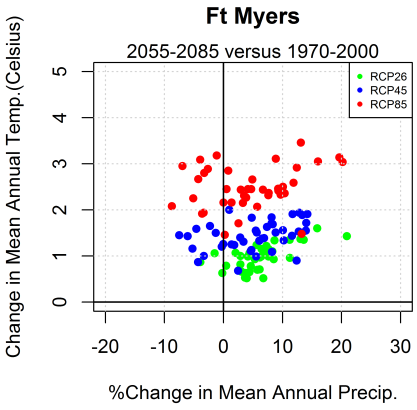
Climate Data Analysis – Point Data – Far Future

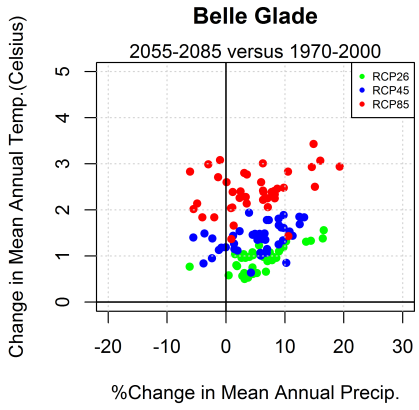


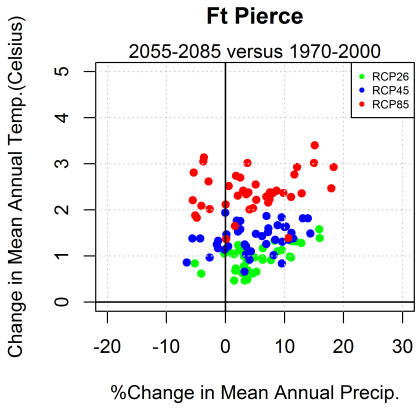






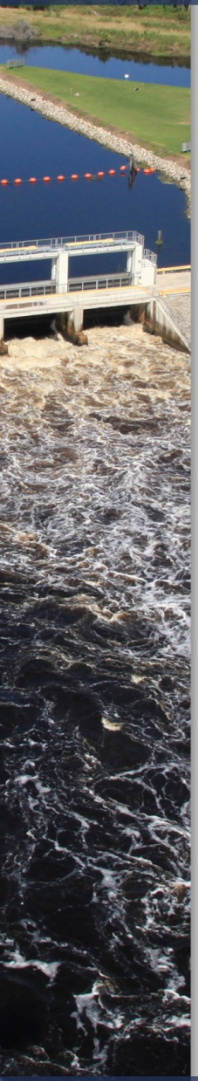


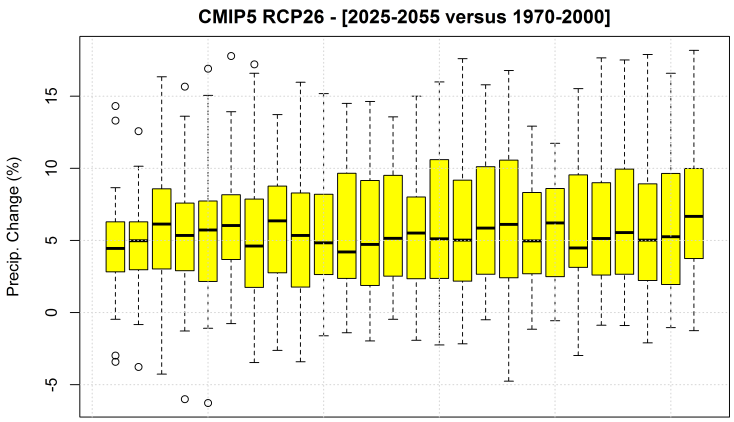


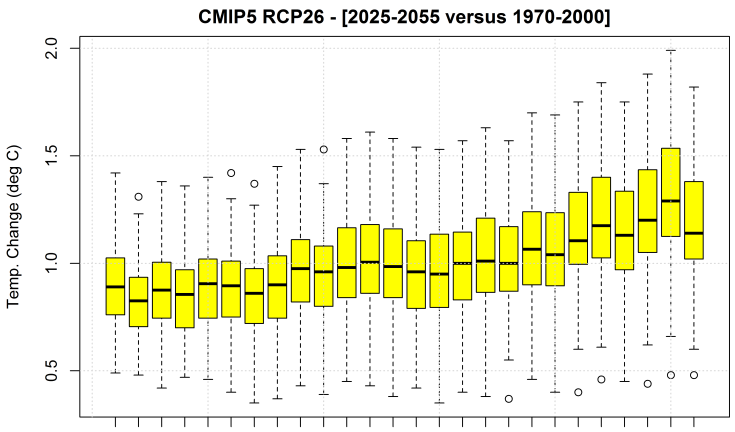


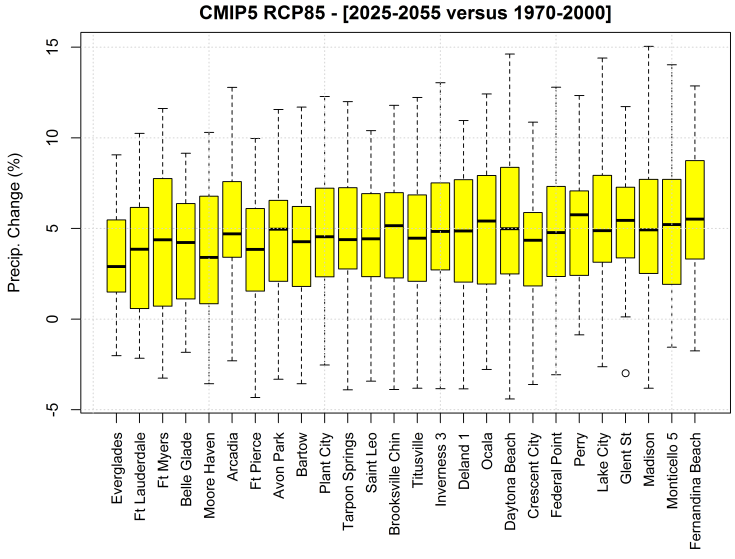
- RCP26
- RCP45
- RCP85

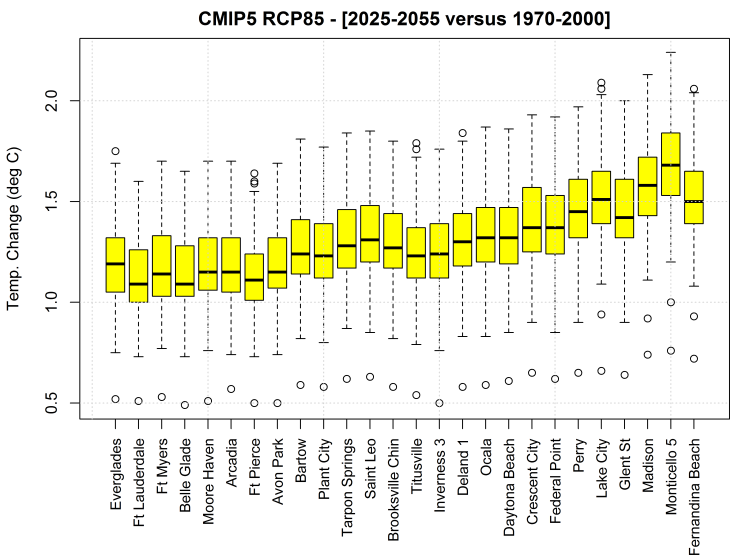
Climate Data Analysis – Point Data – Near Future



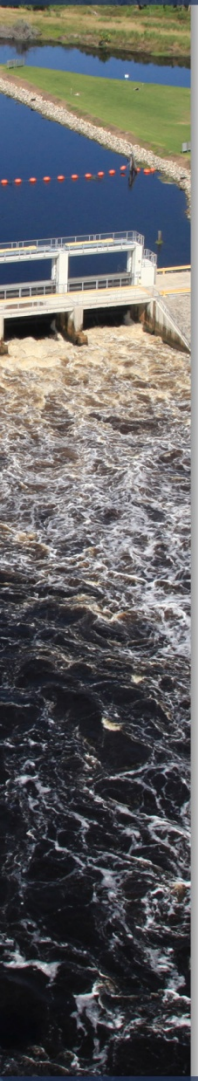




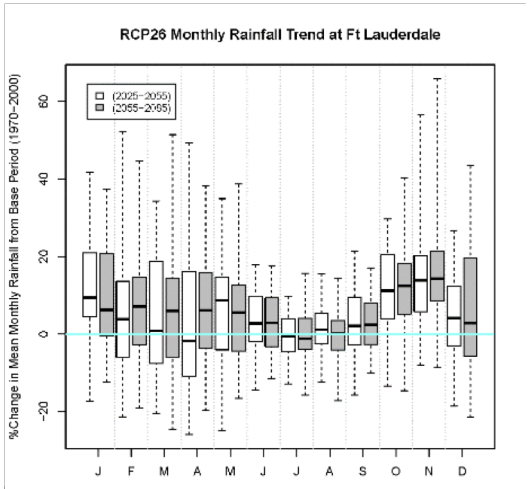


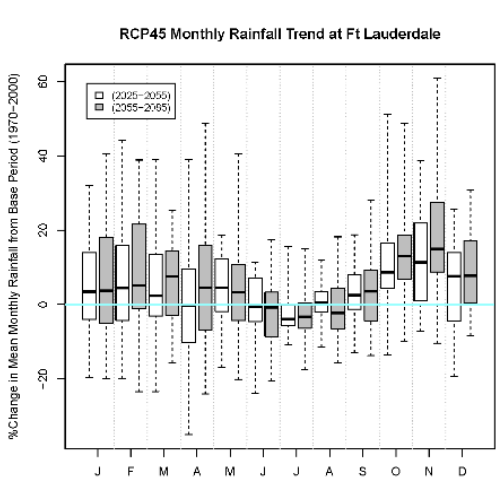


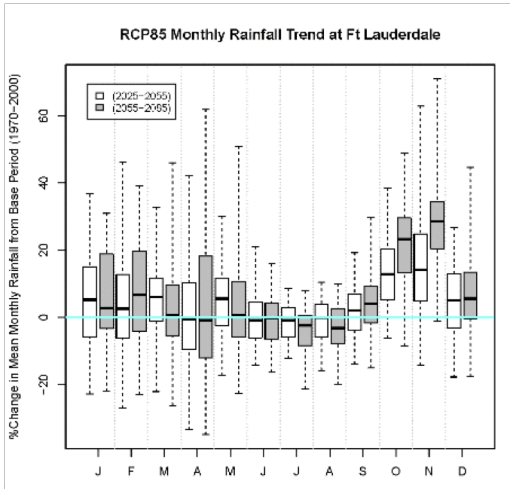
Climate Data Analysis – Point Data – Monthly

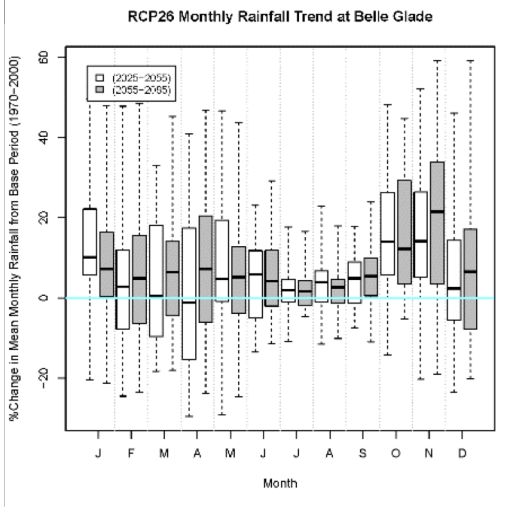


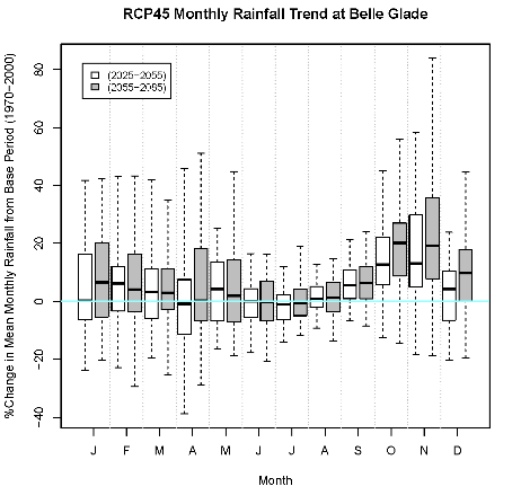
Precipitation

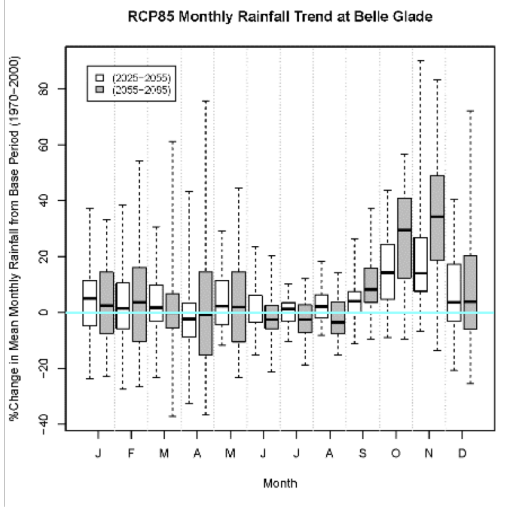




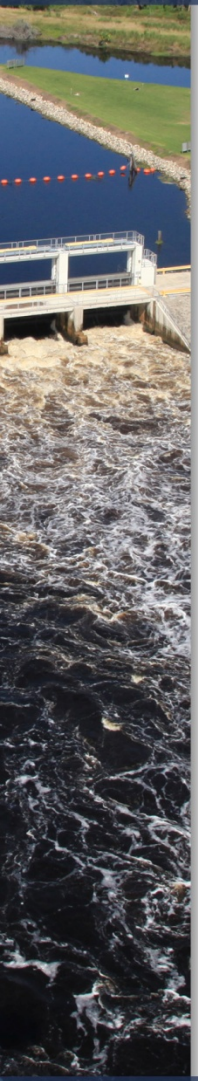




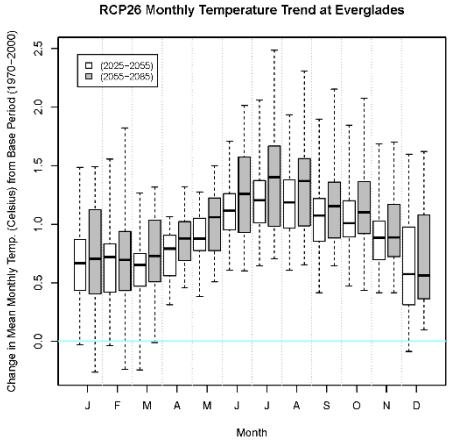


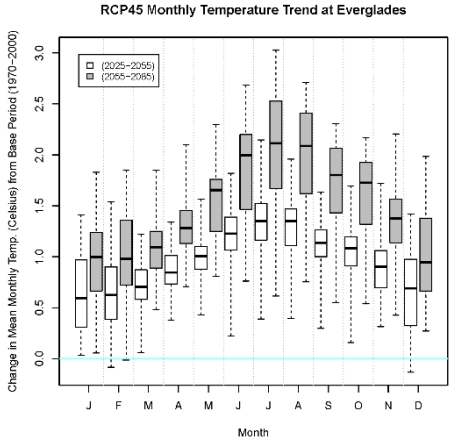


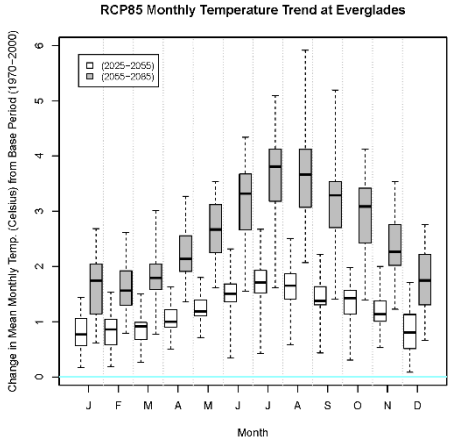
Climate Data Analysis – Point Data – Monthly

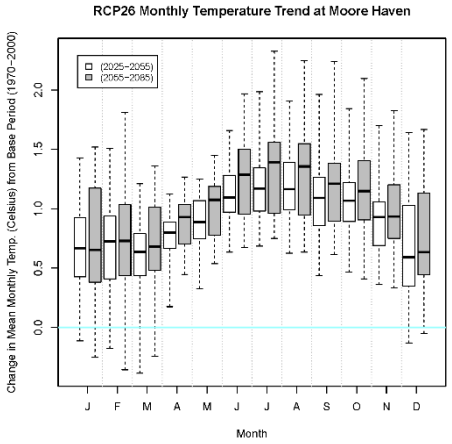


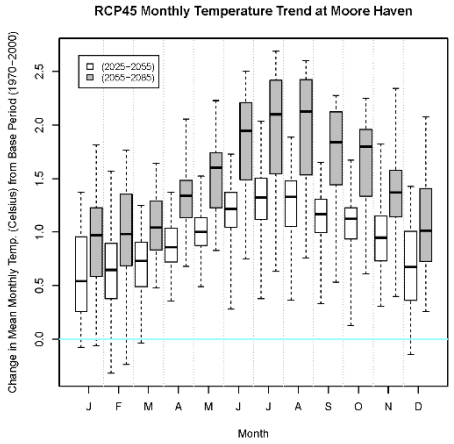
Temperature

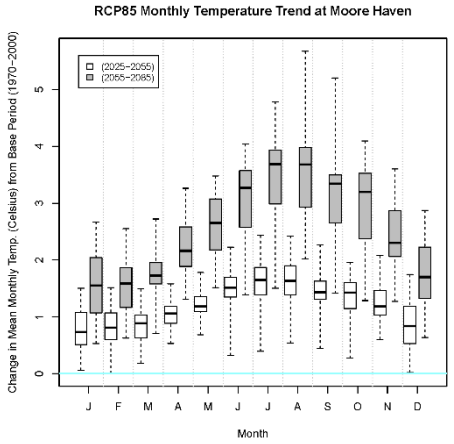




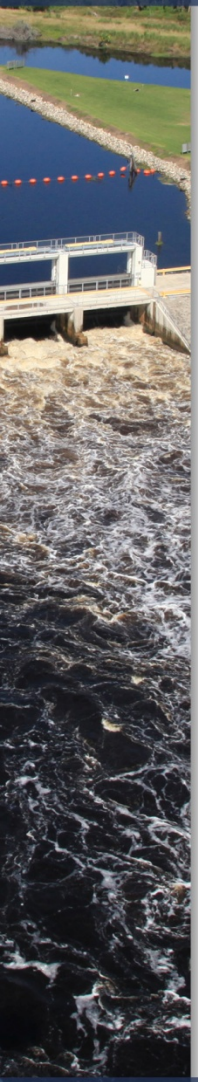








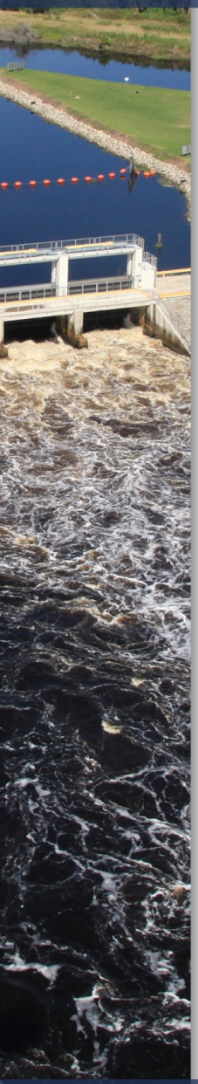
Climate Data Analysis – Point Data



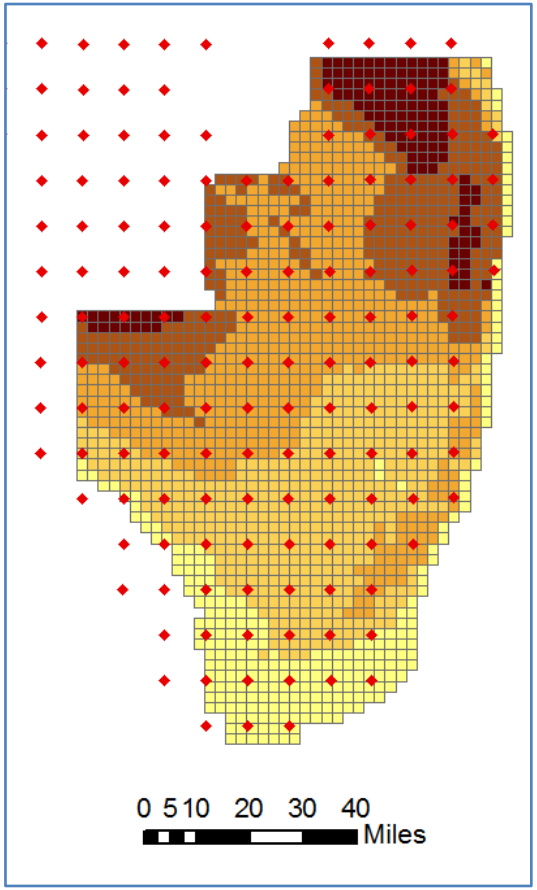
Percent Change in Precipitation		
Scenario	Near Future	Far Future
RCP2.6	[-2.6 to 15.7%]	[-2.3 to 20.2%]
RCP4.5	[-5.7 to 12.6%]	[-6 to 16.5%]
RCP8.5	[-3.3 to 12.3%]	[-7.6 to 20%]

Change in Average Temperature		
Scenario	Near Future	Far Future
RCP2.6	[0.4 to 1.6°C]	[0.5 to 1.8°C]
RCP4.5	[0.4 to 1.7°C]	[0.8 to 2.2°C]
RCP8.5	[0.6 to 1.9°C]	[1.6 to 3.7°C]

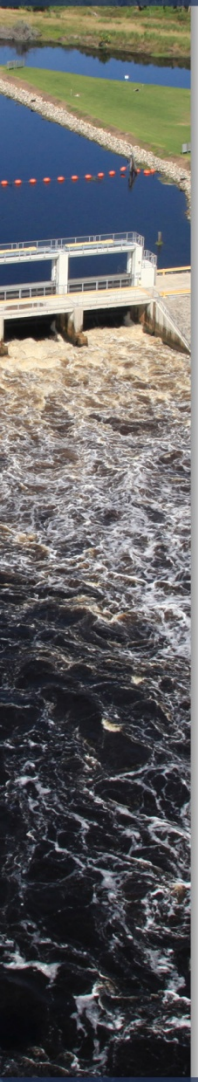
Climate Data Analysis – Rainfall - SFWMM

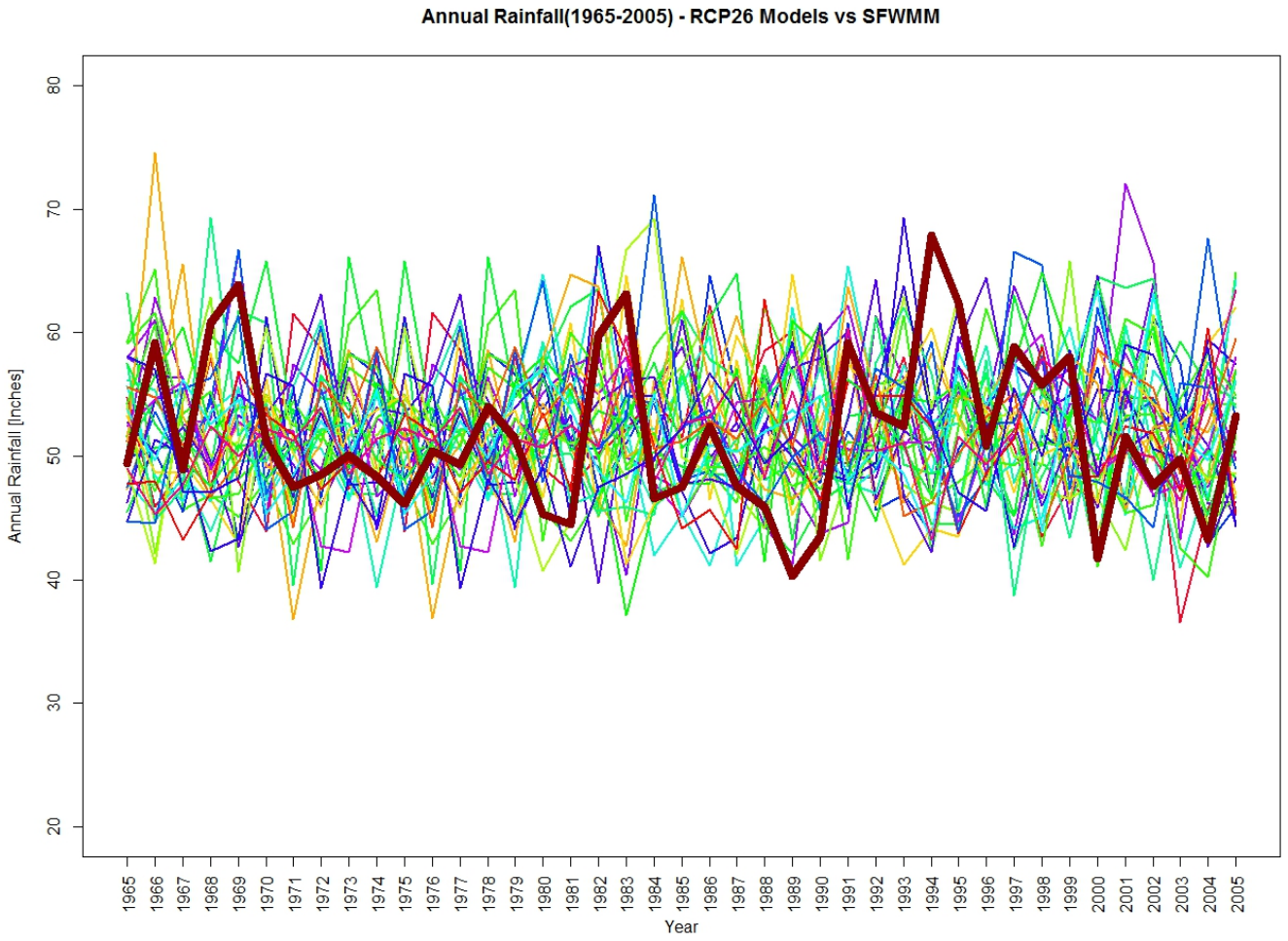


- SFWMM model domain has 2 miles x 2 miles grid
- Historical daily rainfall timeseries over the model grid covering 1965-2005

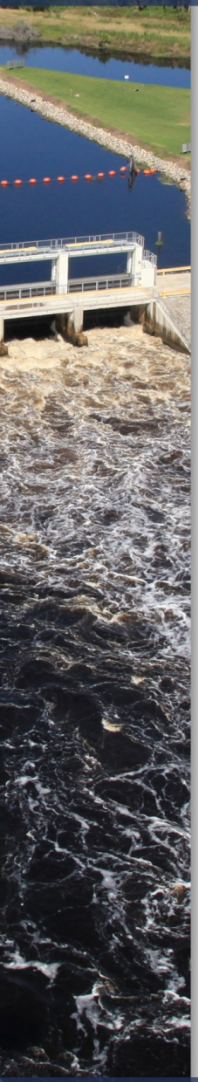


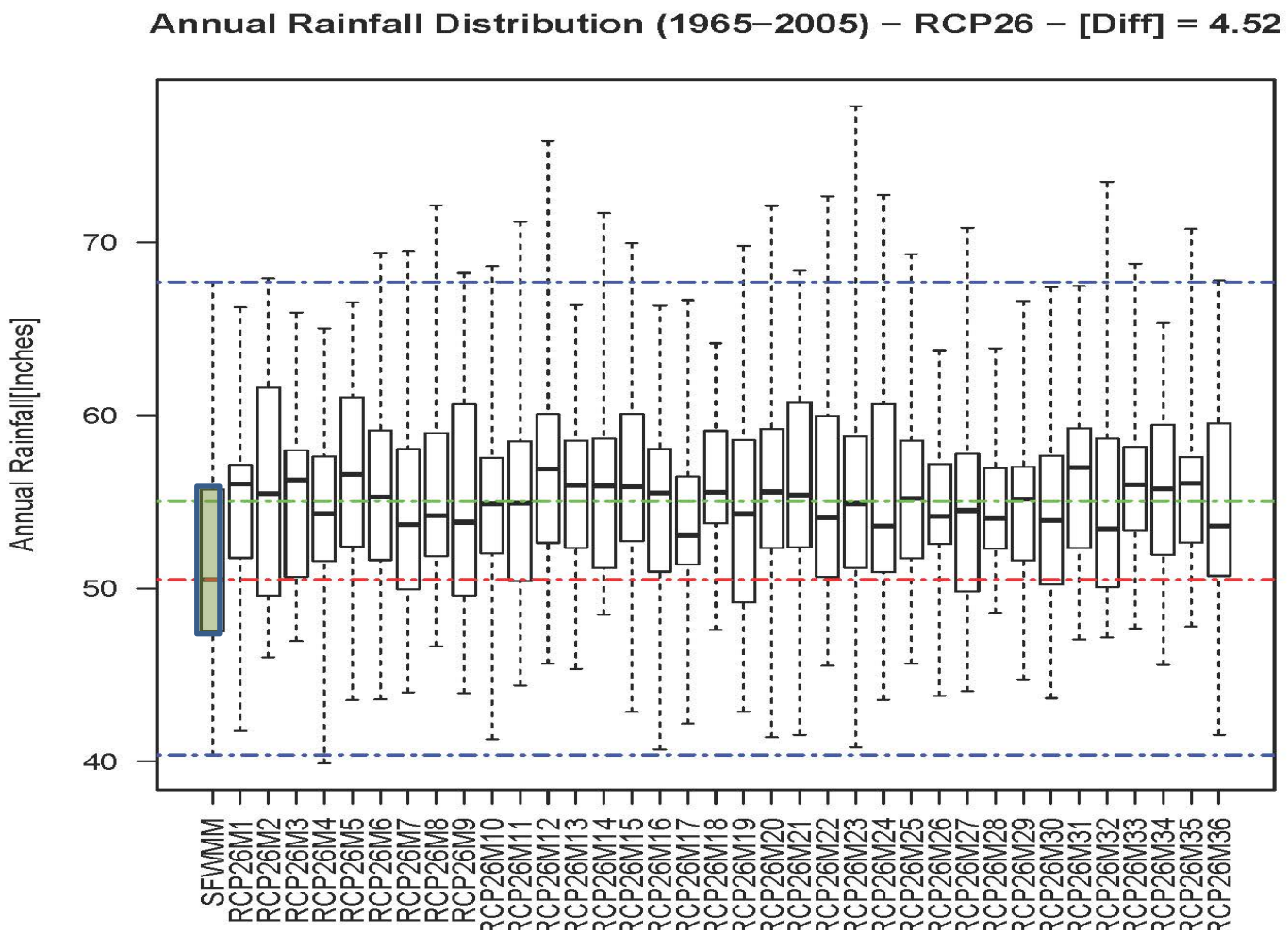
Climate Data Analysis – Rainfall - SFWMM



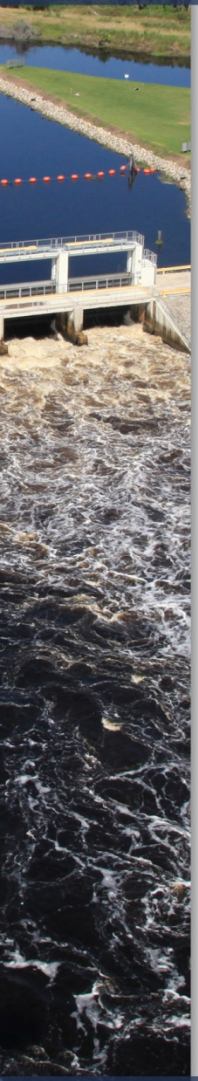


Climate Data Analysis – Areal Rainfall - SFWMM

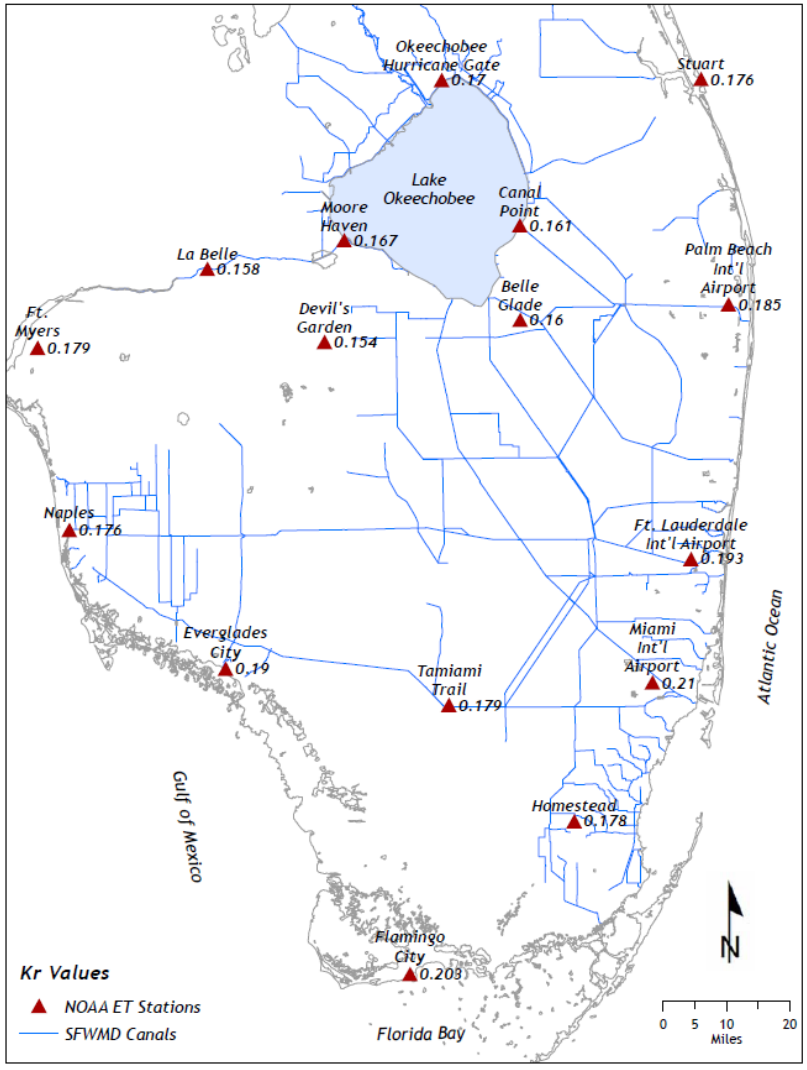




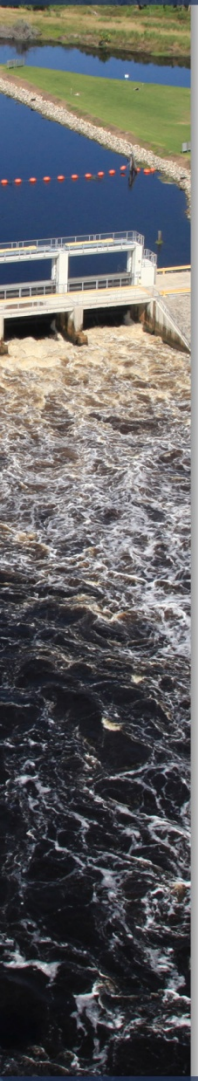
Climate Data Analysis - Evapotranspiration

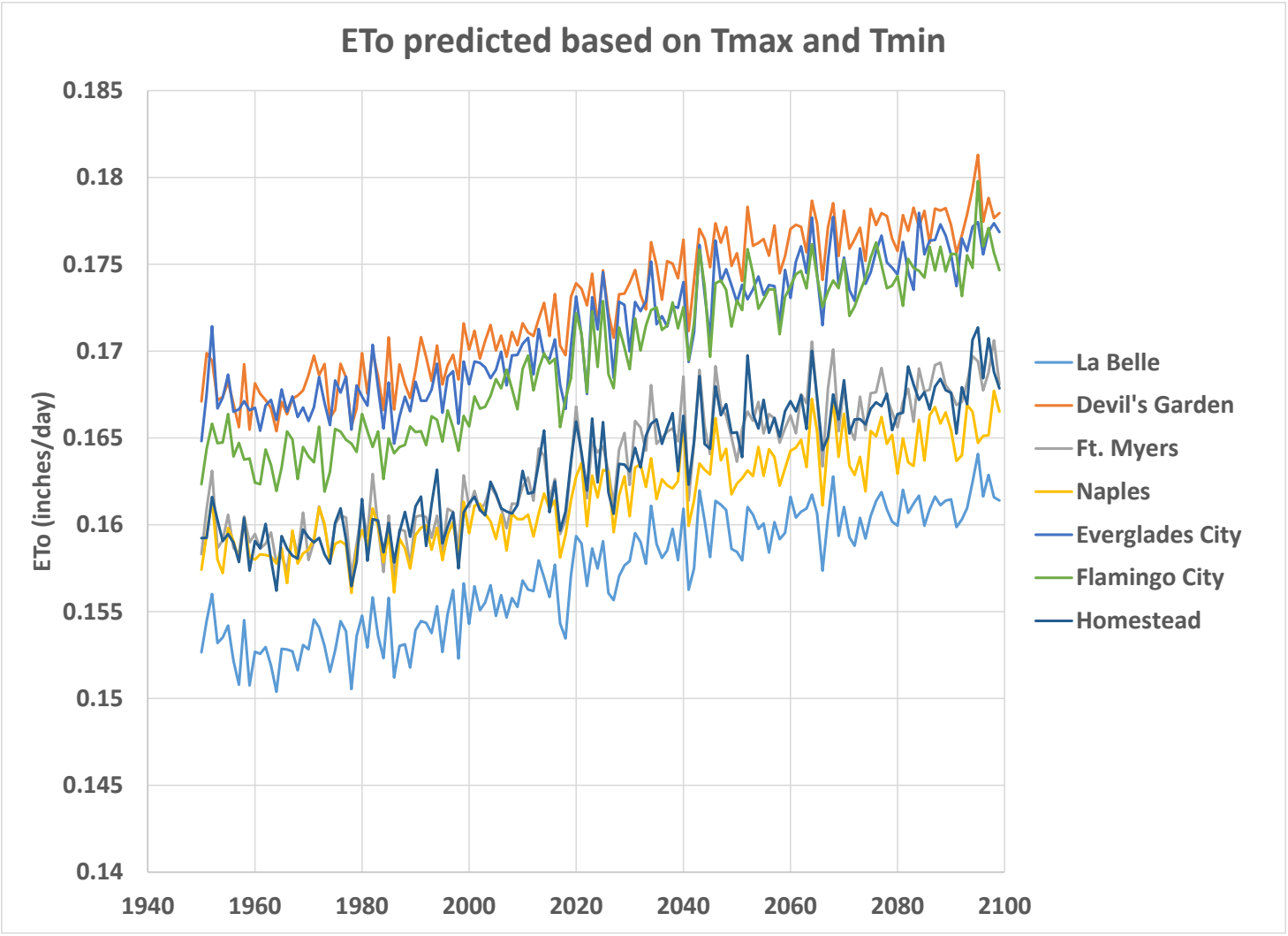


- 17 NOAA weather stations were used to calibrate Hargreaves-Samani Equation for empirical coefficient (KT)
- Historical ETo for the period 1965 to 2005 was used from SFWMM regional model
- Linear regression was employed to calculate KT for each of the 17 stations



Climate Data Analysis - Evapotranspiration



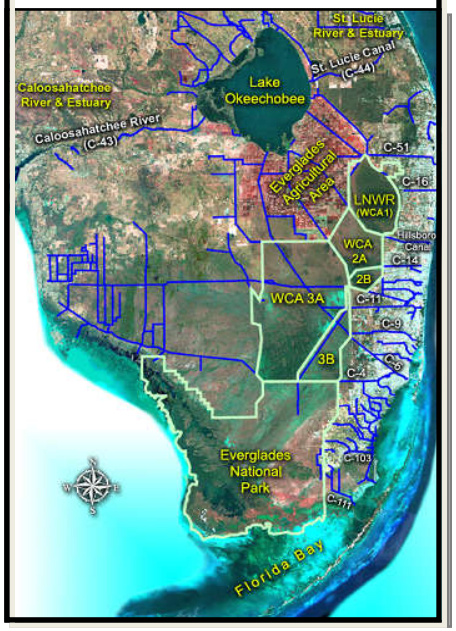


Future Regional Water Resources Assessment

Regional Model (SFWMM/RSM)

- Climatic Input
  - Rainfall
  - ET
- Boundary Conditions

Scenarios



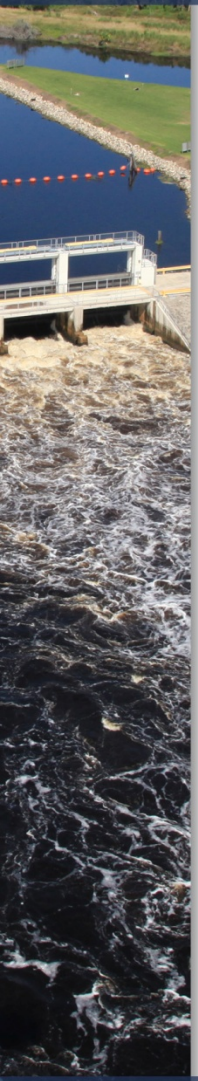
- Land Use/Land Cover
- Water Demands
- Operating Criteria

Model Output

- Daily time series of water levels, flows
- Demands not met

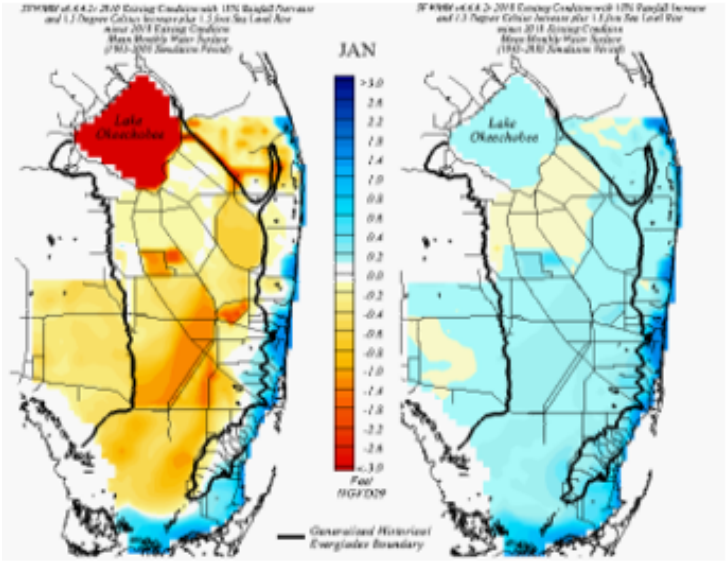
Performance Measures (Ag, Env, Urban)

Future Regional Water Resources Assessment

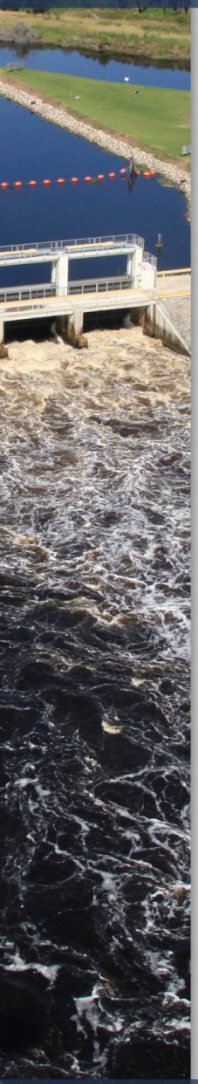


- Previous future regional water resources assessment was based on simplified delta approach
- Scenarios were built based on combinations of Rainfall (percent changes) and Temperature and Sea Level Rise magnitudes
- Base period of simulation was 1965 - 2005

Parameter	Scenario
Rainfall	-10% & 10%
Temperature	1.5°C
Sea Level Rise	1.5 feet



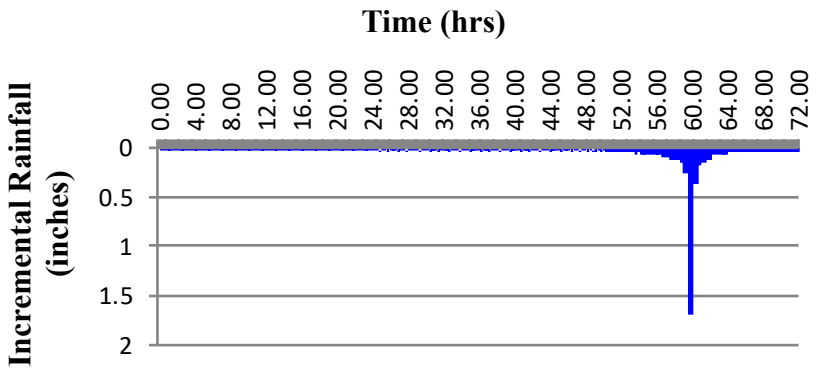
Flood Protection Level of Service (LOS) Program



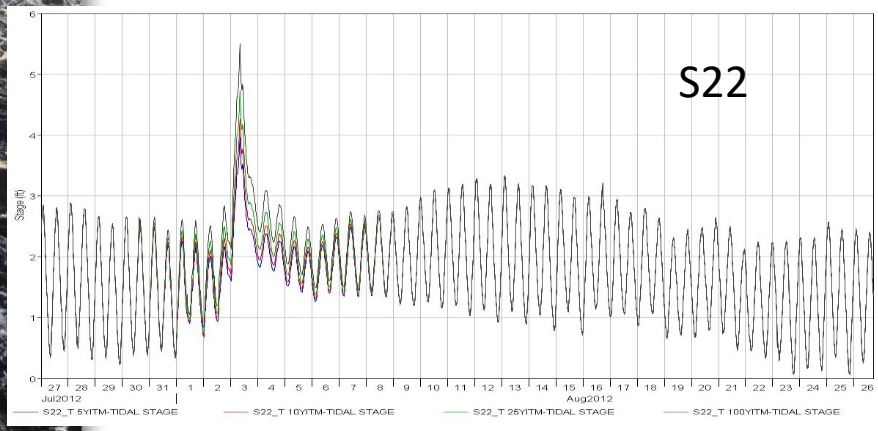
Purpose of Flood Protection LOS program is to identify and prioritize long-term District infrastructure needs.

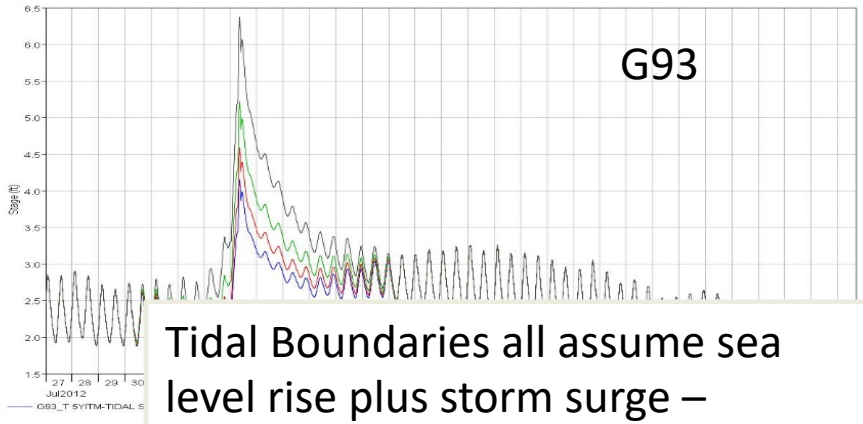
Level of Service projects provide a process to establish flood protection thresholds for each basin. These thresholds will help initiate retrofits and other adaptation efforts.

Model Drivers: Rainfall and Boundary Stage Time-Series



Design rainfall follows SFWMD 3-D pattern – intense peak storm

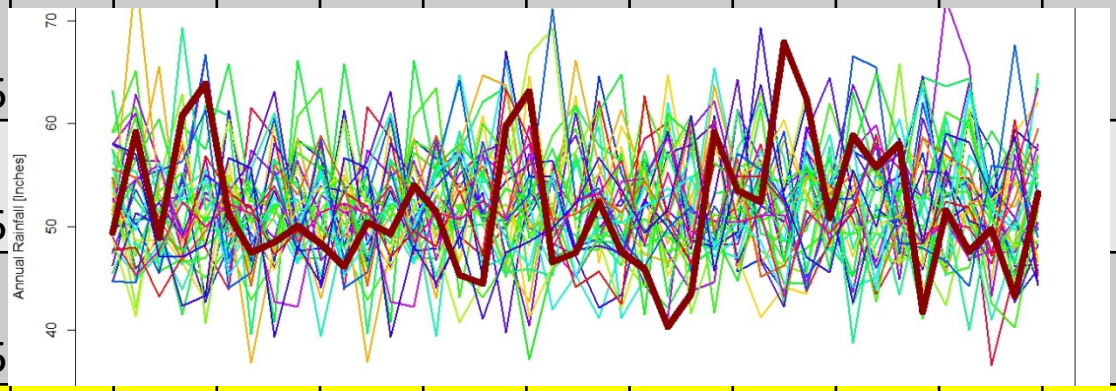




Tidal Boundaries all assume sea level rise plus storm surge – different for each structure

Models and Ensembles – Too many and need for scenario-based approach

	BCC	CCCMA	CNRM-CERFACS	CSIRO-BOM	CSIRO-QCCCE	INM	IPSL	MIROC	MIROC2	MPI-M	MRI	NCC	NOAA GFDL	NSF-DOE-NCAR	RSMAS	Total
RCP26	1	5											3	0	2	36
RCP45	1	5											2	1	2	42
RCP85	1	5											3	1	2	41
Total	3	15	2	2	30	2	14	9	6	14	3	3	8	2	6	119

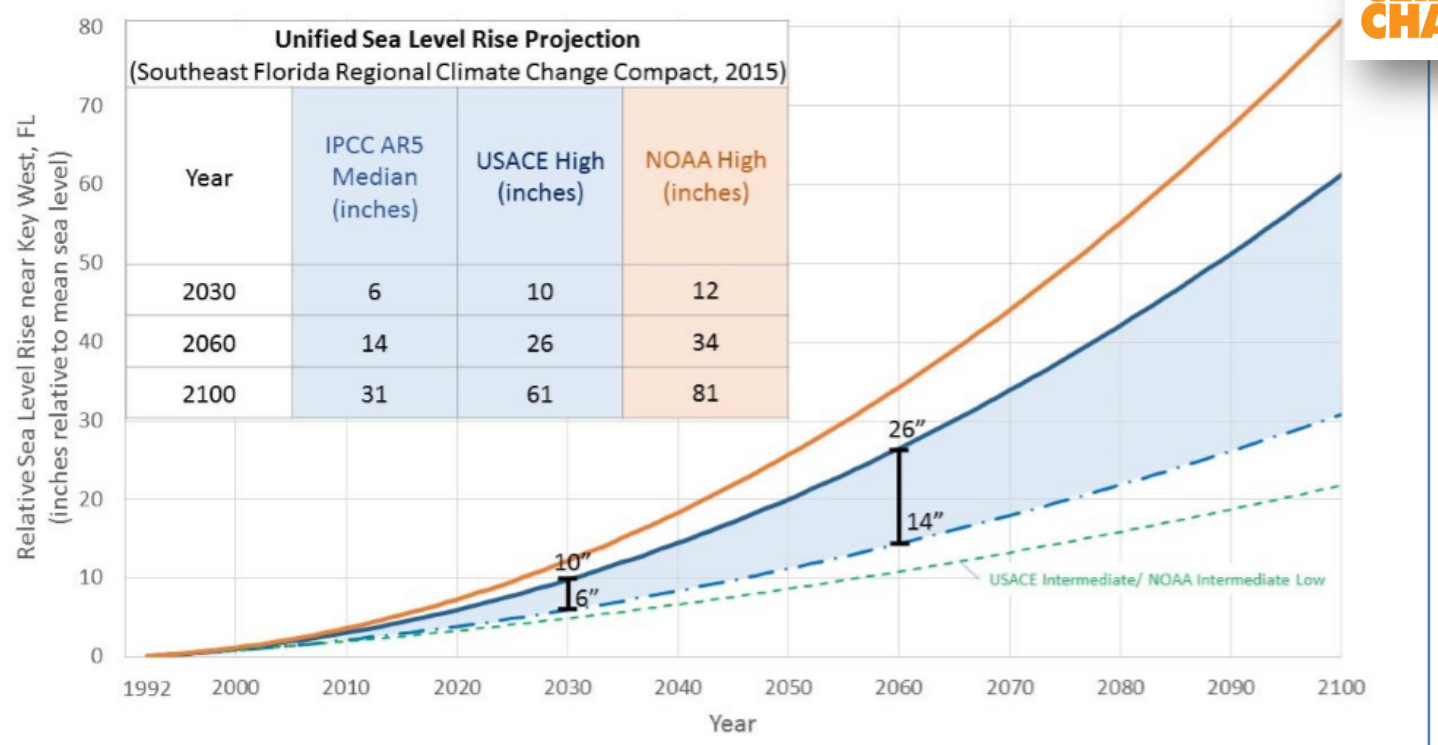


A step towards unified scenario approach

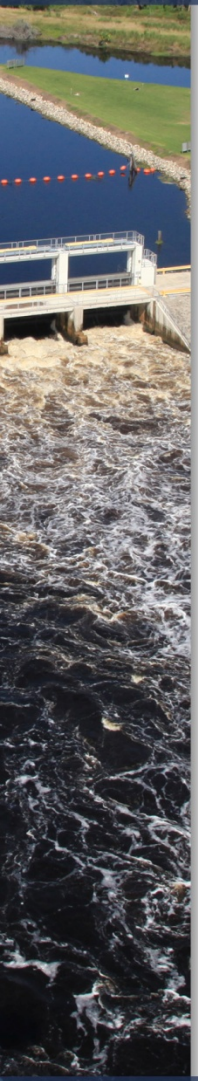
- Unified sea level rise projections from Southeast Florida regional compact

Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

Year	IPCC AR5 Median (inches)	USACE High (inches)	NOAA High (inches)
2030	6	10	12
2060	14	26	34
2100	31	61	81

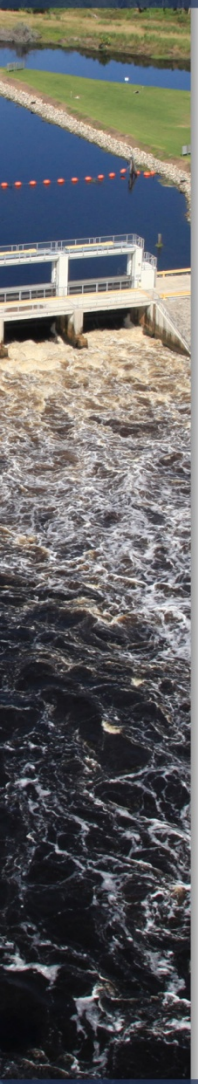


Summary & Conclusions



- Daily CMIP5 rainfall dataset covering 1950 to 2099 was downscaled to the South Florida regional models (SFWMM & RSM) for three RCP scenarios (119 in total)
- Daily Evapotranspiration was calculated for the period 1950 to 2099 from Tmin and Tmax CMIP5 dataset (119 in total)
- Based on point rainfall dataset at 32 selected Florida gages, rainfall change ranges for the near future (2025-2055) and far future (2055-2085) depending on the RCP scenarios and climate model
- Based on point average temperature dataset at 32 selected Florida gages, average temperature increases for the near future (2025-2055) and far future (2055-2085) depending on the RCP scenarios and climate model
- Development of unified future climatic scenarios for Florida is essential.

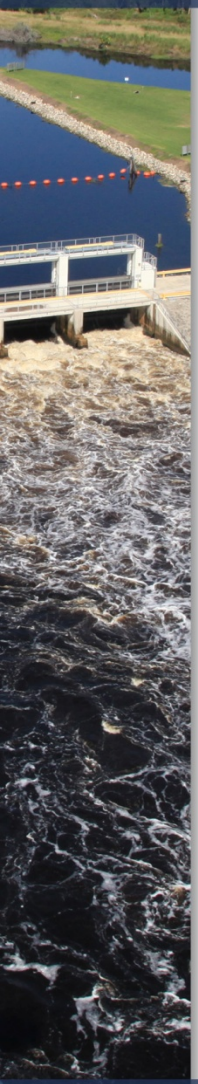
Summary & Conclusions



- Future climate scenarios should include:
  - Daily or sub-daily rainfall time series at smaller spatial scale (e.g. 2 miles x 2 miles)
  - Daily or sub-daily evapotranspiration time series at smaller spatial scale (e.g. 2 miles x 2 miles)
  - Change in Intensity-Duration-Frequency curves


Thank You!

Climate Data Analysis - Evapotranspiration



- Hargreaves and Samani (1982) equation is employed to calculate future Evapotranspiration based on temperature projections

$$ET_O = 0.0135(KT)(R_a)(TD)^{1/2}(TC + 17.8)$$

where:

- TD = Difference between maximum and minimum daily temperatures (°C)
- TC = Average daily temperature (°C)
- R_a = Extraterrestrial radiation (mm/day)
- KT = Empirical coefficient