Climate Change Scenarios for CERP Vulnerability Assessment

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SCG Science Meeting, SFWMD (January 23, 2015)

Outline

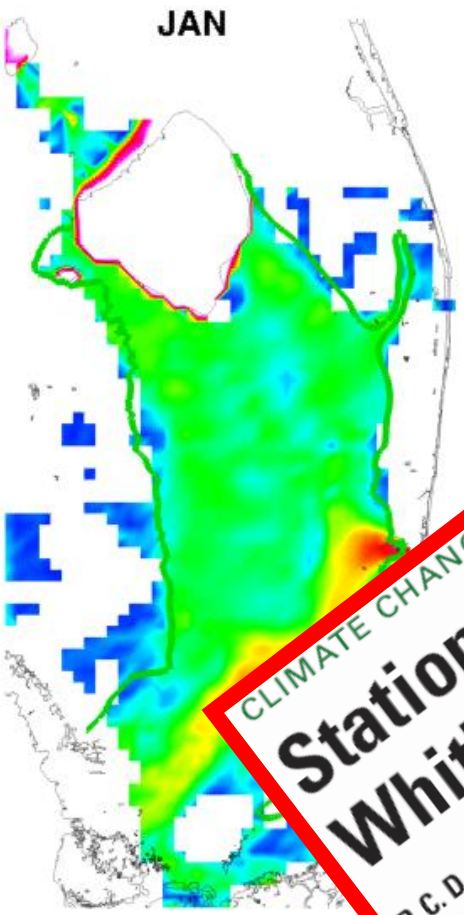
- Climate Change & CEMs
- Projected Changes in Temperature, Precipitation, and Sea Level Rise
- Datasets and Impact Assessments To Date
  - Scenarios which served as the basis for a series of papers in Environmental Management journal (April 2015)
- Potential Next Steps

Acronyms

Acronym	Description	Acronym	Description
AMO	Atlantic Multi-decadal Oscillation	GCM	General Circulation Model
AOGCM	Atmosphere-Ocean GCMs	IPCC	Intergovernmental Panel on Climate Change
AR4	IPCC Assessment Report #4 (~2007)	LOCA	Localized Constructed Analogs
AR5	IPCC Assessment Report #5 (~2013)	NARCCAP	North American Regional Climate Change Assessment Program
CEM	Conceptual Ecological Model	NCAR	National Center for Atmospheric Research
CMIP3	Coupled Model Intercomparison Project #3	PDO	Pacific Decadal Oscillation
CMIP5	Coupled Model Intercomparison Project #5	RCP	Representative Concentration Pathways
ENSO	El Nino-Southern Oscillation	SLR	Sea Level Rise

Everglades Restoration – Do we need a new paradigm for planning?

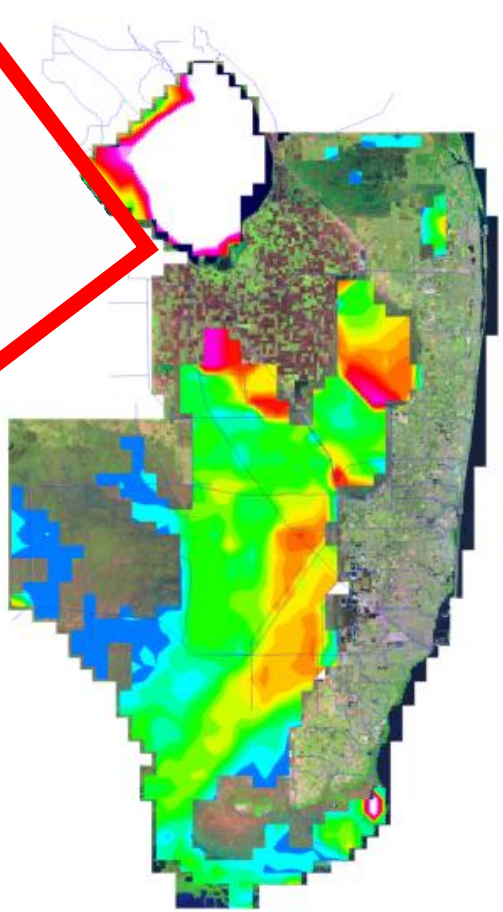
Natural System **Managed System** **CERP**



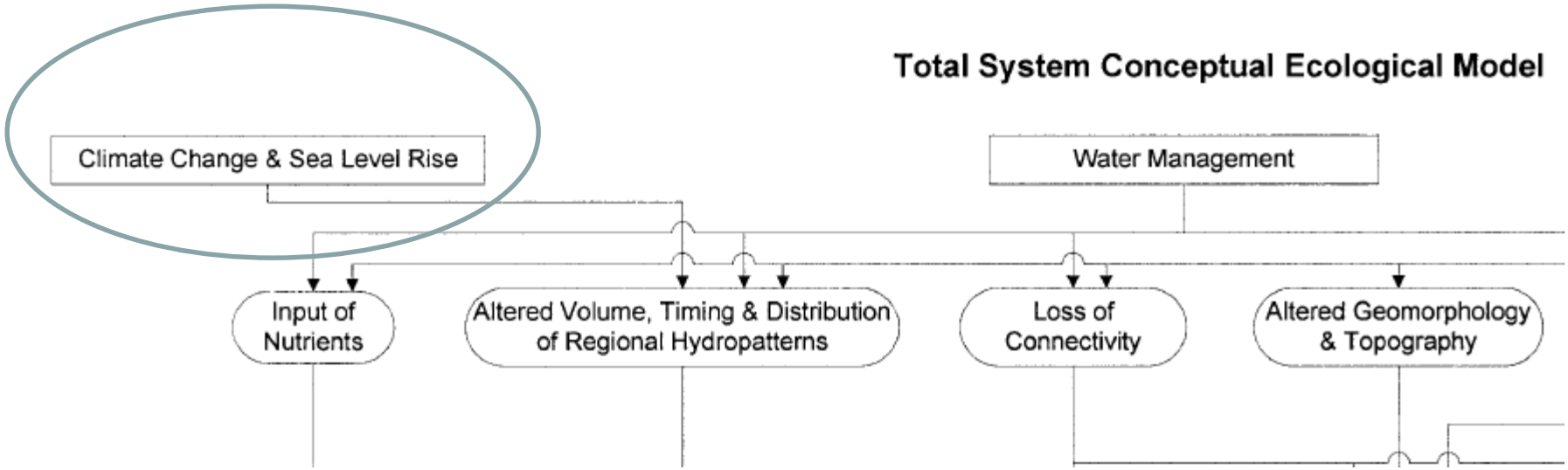
CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]



Climate Change/SLR in CEMs



- Fast becoming an important “Driver”
- Range of projections and their implications?

Potential Impacts on Water Resources Management in South Florida

Quartet of change: Drivers*

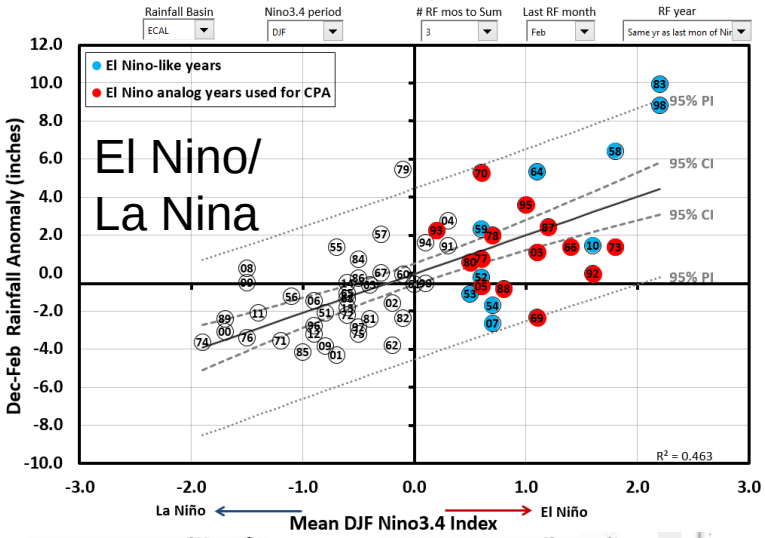
- Rising Sea Levels
- Temperature (& ET)
- Rainfall (both averages & extremes)
- Tropical Storms & Hurricanes

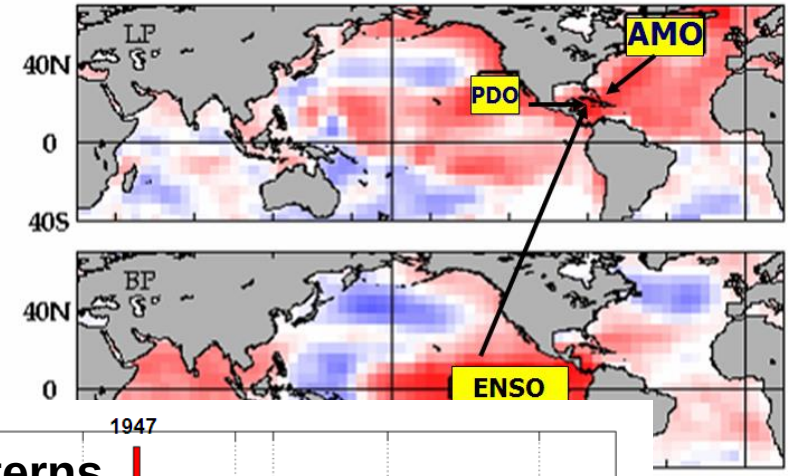
Water Management Impacts

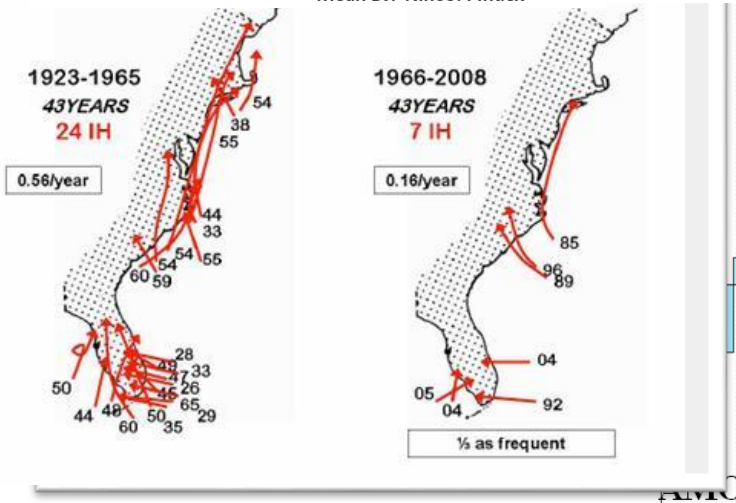
- Direct landscape impacts (e.g. storm surge)
- Water Supply (e.g., saltwater intrusion)
- Flood Control (e.g. urban flooding)
- Natural Systems (e.g. ecosystem impacts, both coastal and interior)

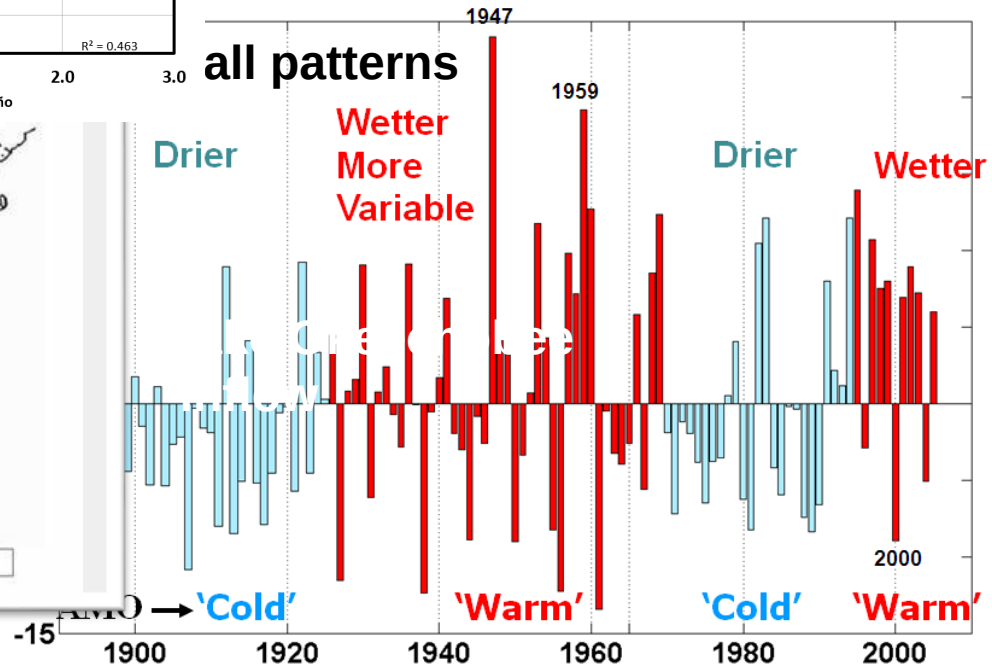
* Natural and Human-Induced

Natural Variability (Teleconnections)

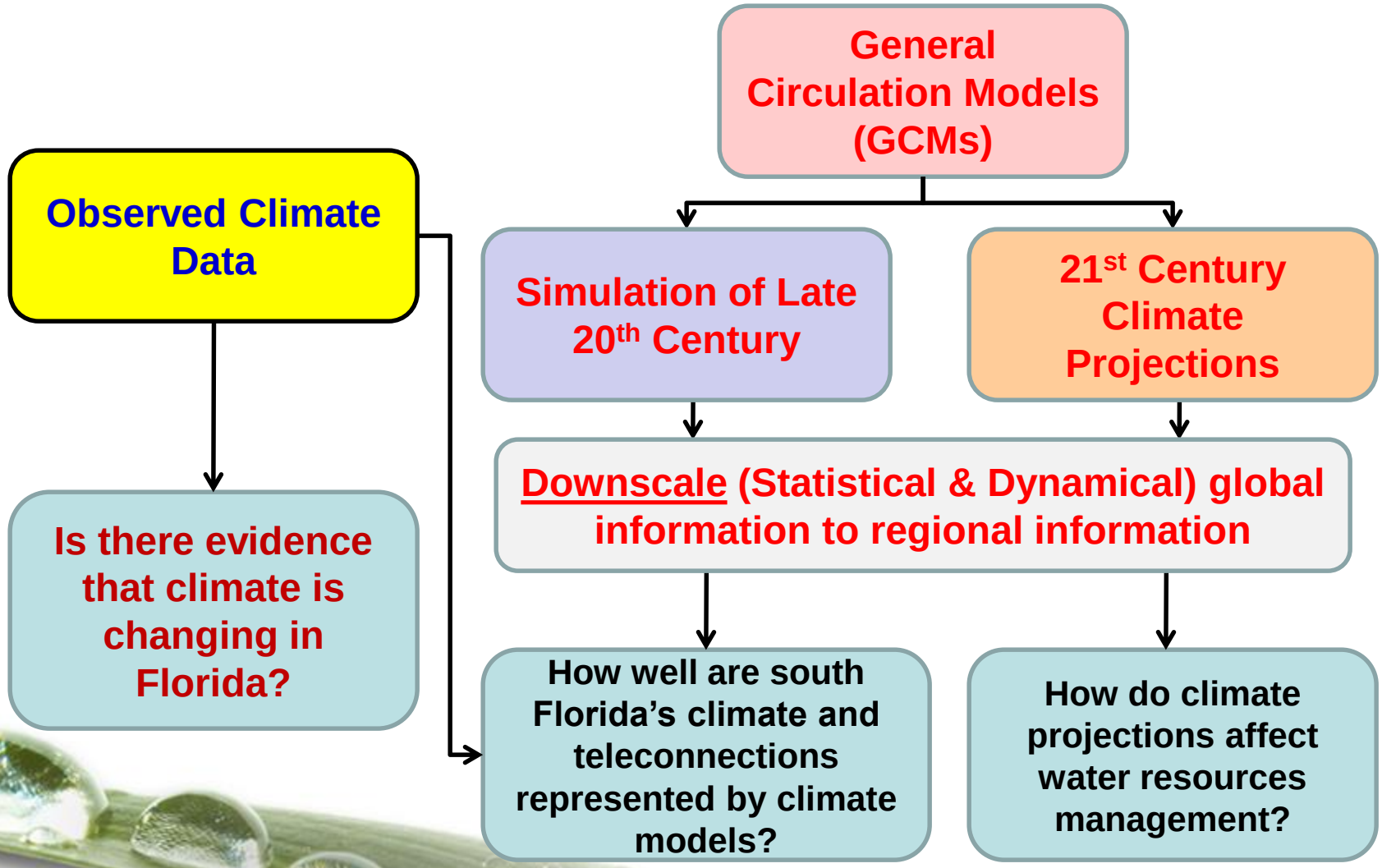








Using Climate Change Information



Trend Analysis of Florida Data (Irizarry et al. 2011)

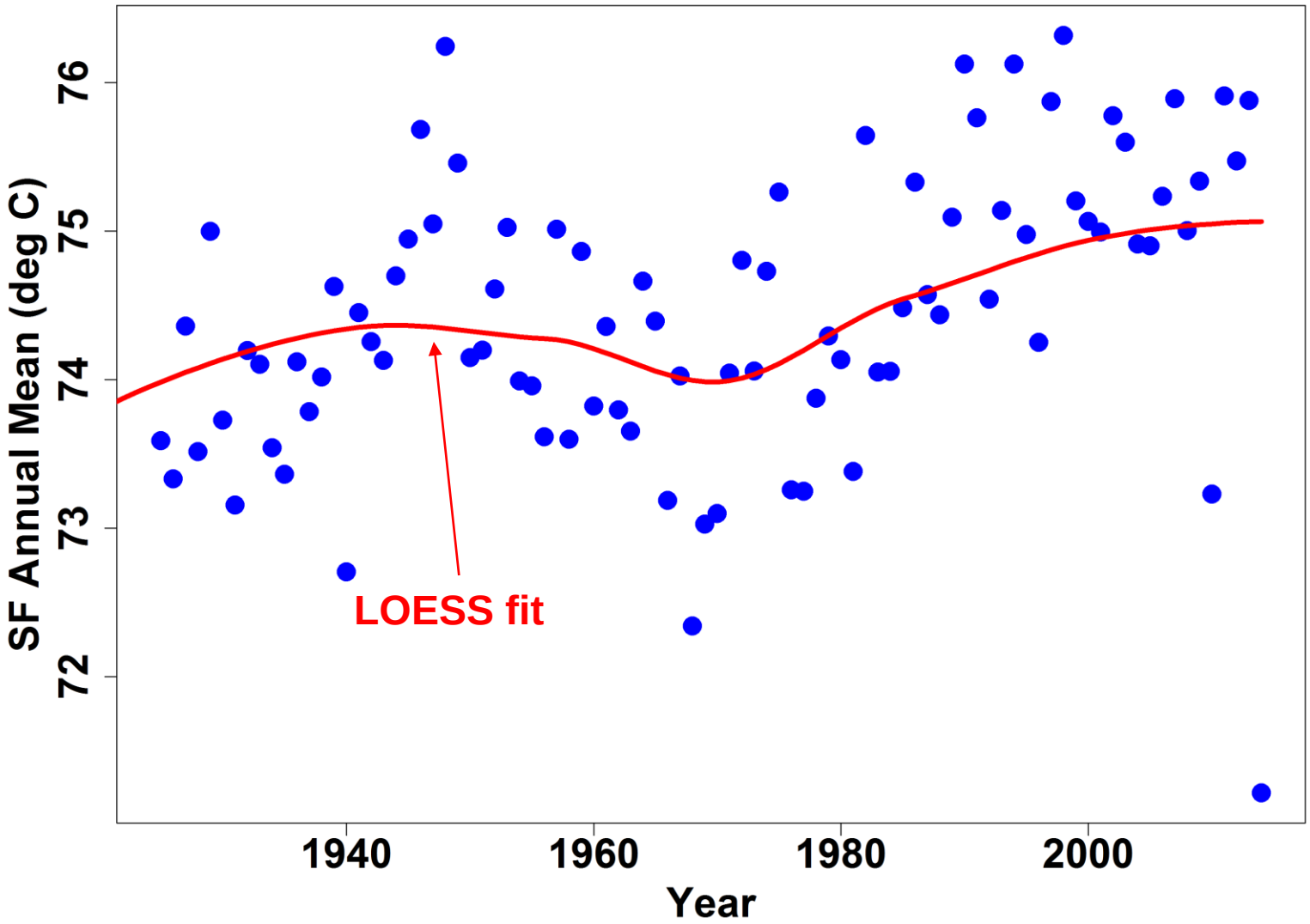
↑ number of wet days during the dry season – POR

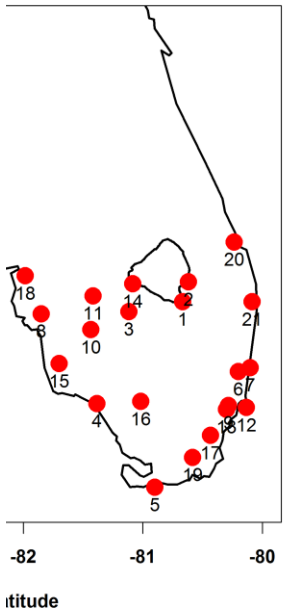
↓ May precipitation throughout the state – POR and especially post-1950. ***May*** be linked to changes in start of the wet season.

Urban heat island effect – urban (and drained) areas

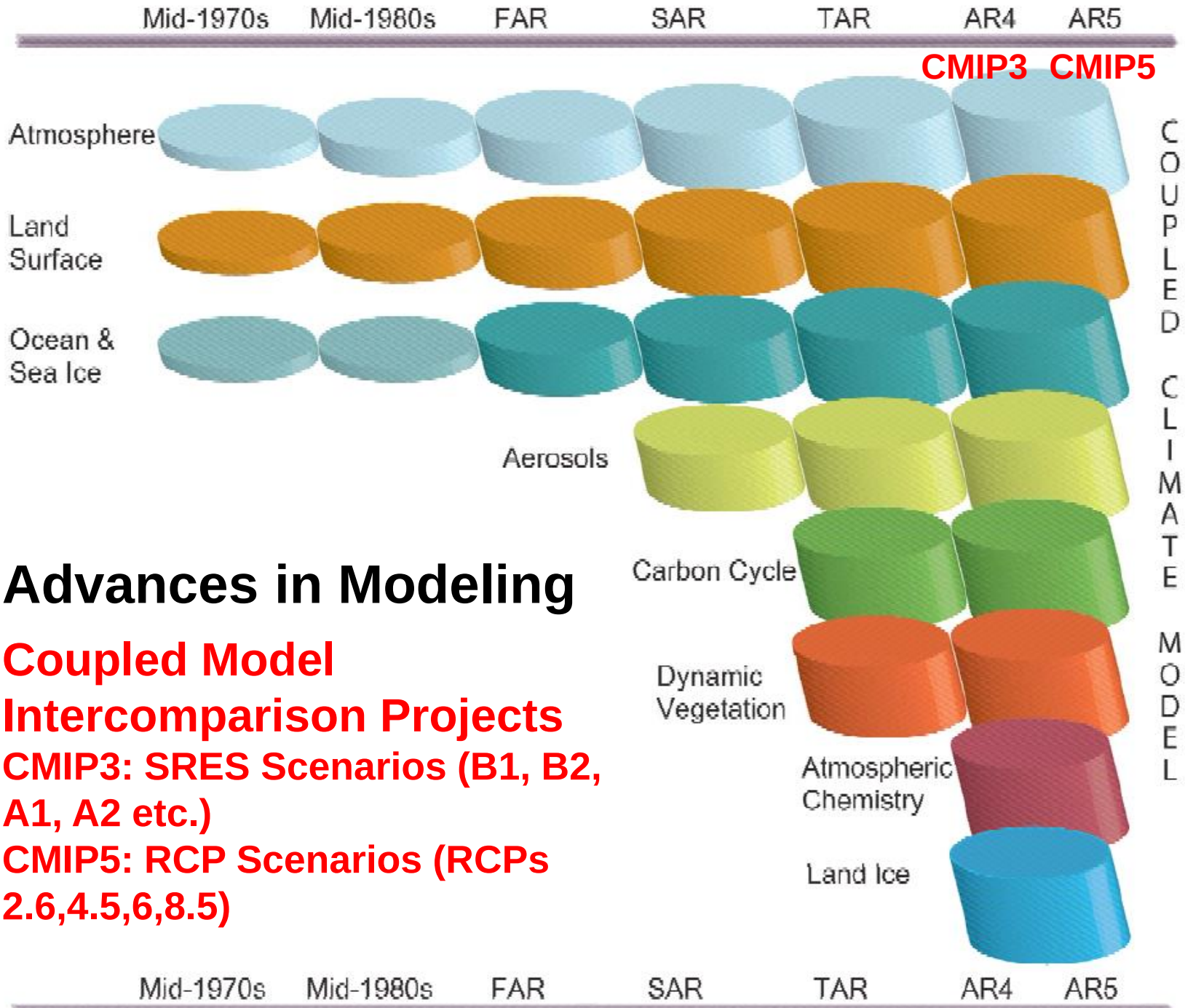
- ↑ Tavg and ↑ number of dog days for wet (warm) season especially post-1950
- Decrease in DTR (↑ Tmin > ↑ Tmax)
- ↑ Annual maximum of Tave and Tmin for all seasons in POR and especially post-1950

Temperature trends in South Florida





Projections



Advances in Modeling

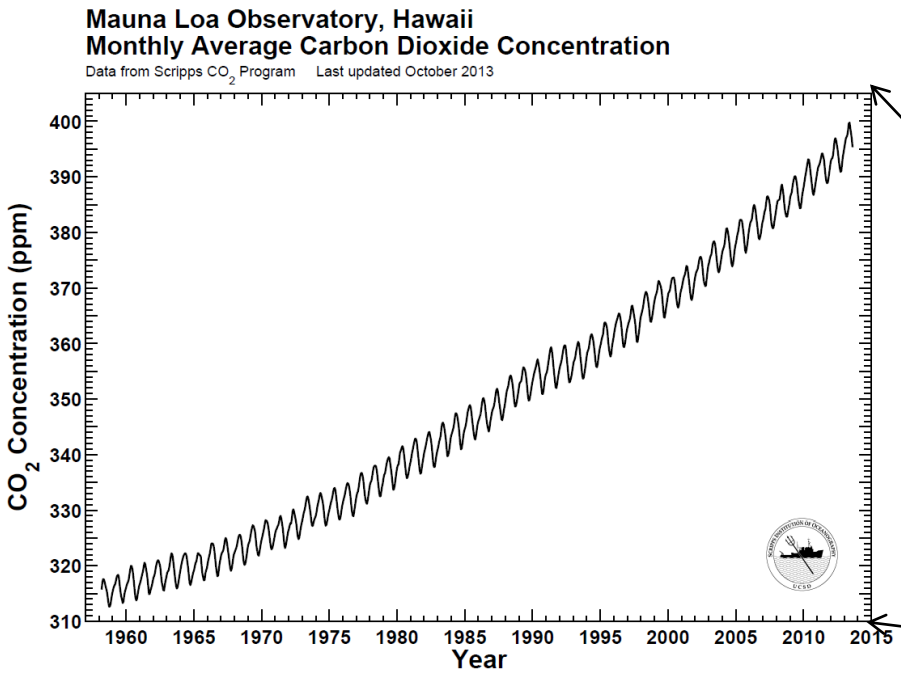
Coupled Model Intercomparison Projects

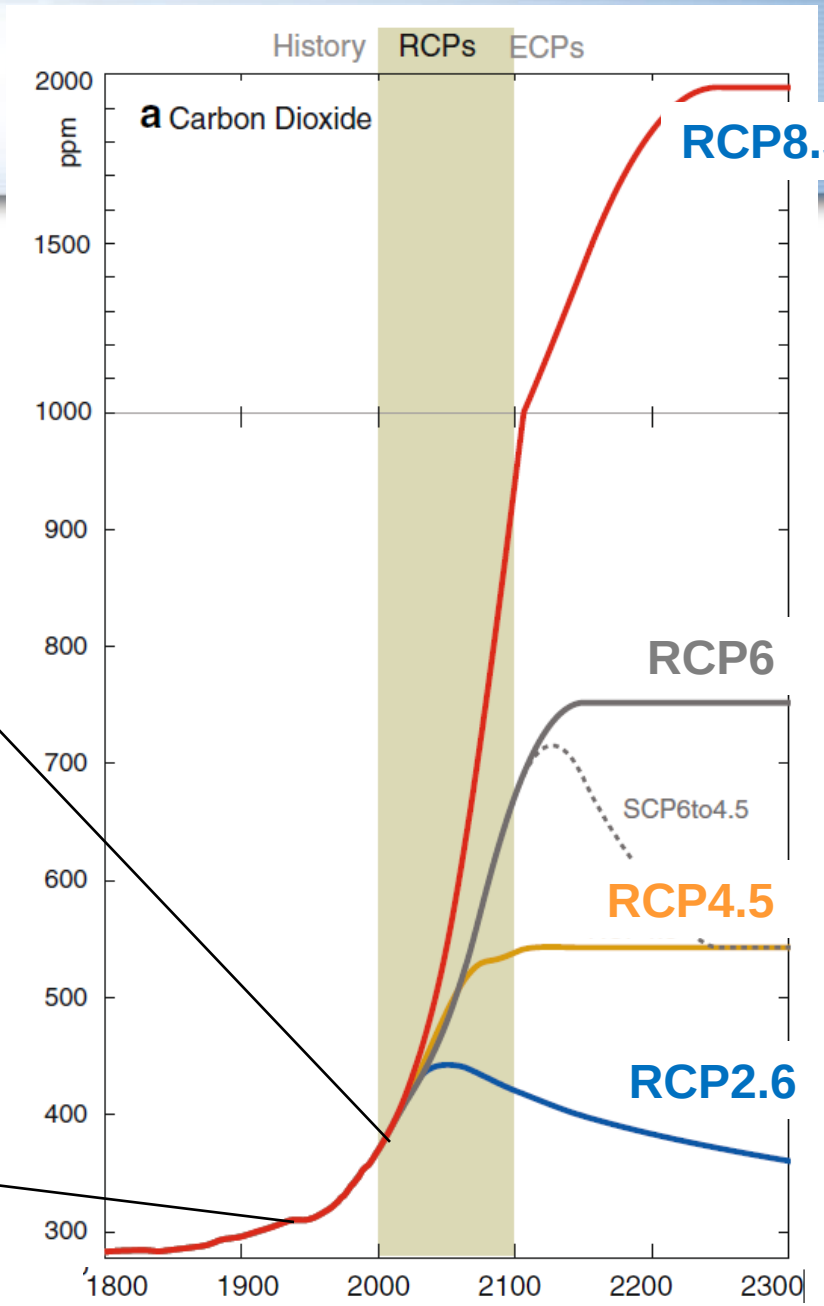
CMIP3: SRES Scenarios (B1, B2, A1, A2 etc.)

CMIP5: RCP Scenarios (RCPs 2.6,4.5,6,8.5)

AR5: Representative Concentration Pathways

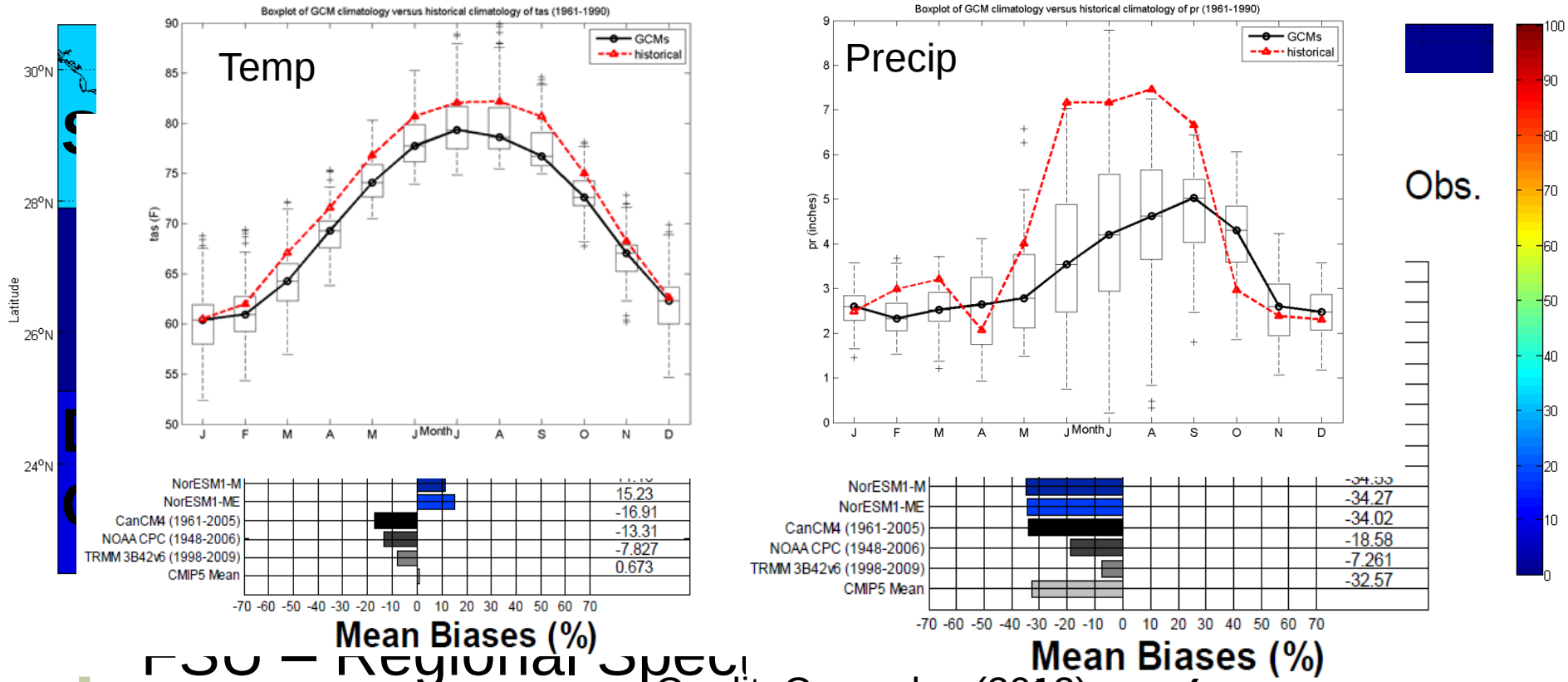
New IPCC (AR5) Approach for Greenhouse Gas Scenarios*





Meinshausen et al. 2011

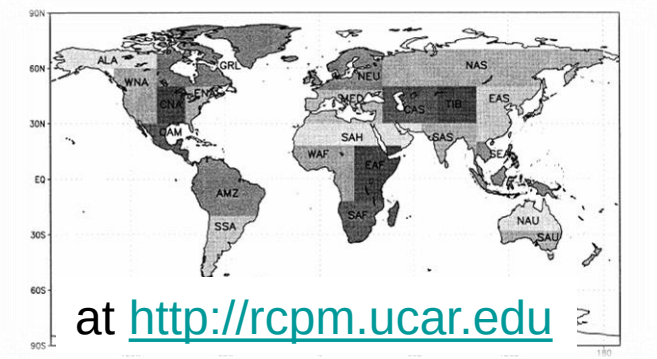
GCM Skills in Florida



- FSU – Regional Spec

Credit: Cespedes (2012)

Regional Climate Change Projections from Multi-Model Ensembles (Tebaldi et al., 2008)



MODEL

Likelihood:

Observed: $X_0 \sim N[\mu, -\lambda_0^{-1}]$

GCM (current): $X_i \sim N[\mu, -\lambda_i^{-1}]$

GCM(future): $Y_i \sim N[\nu, -(\theta\lambda_i)^{-1}]$

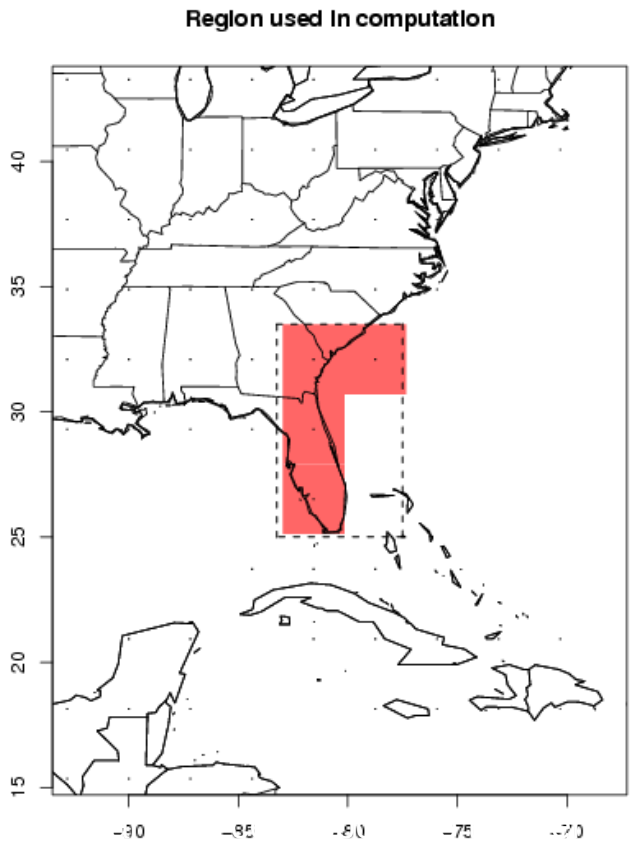
Priors:

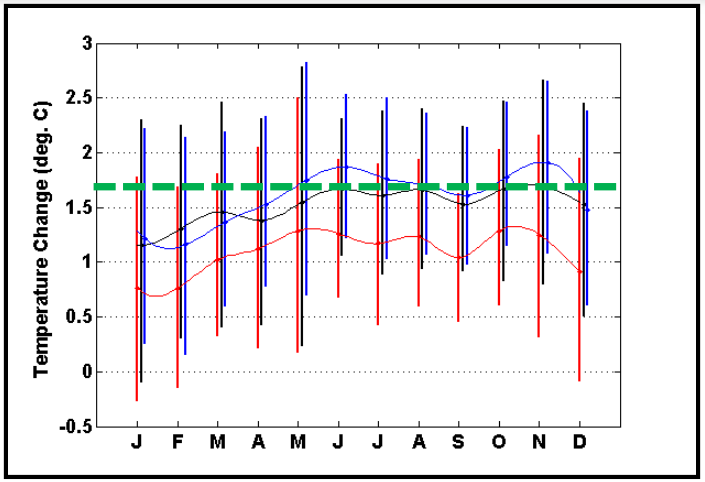
$\mu, \nu \sim U(-\infty, +\infty)$

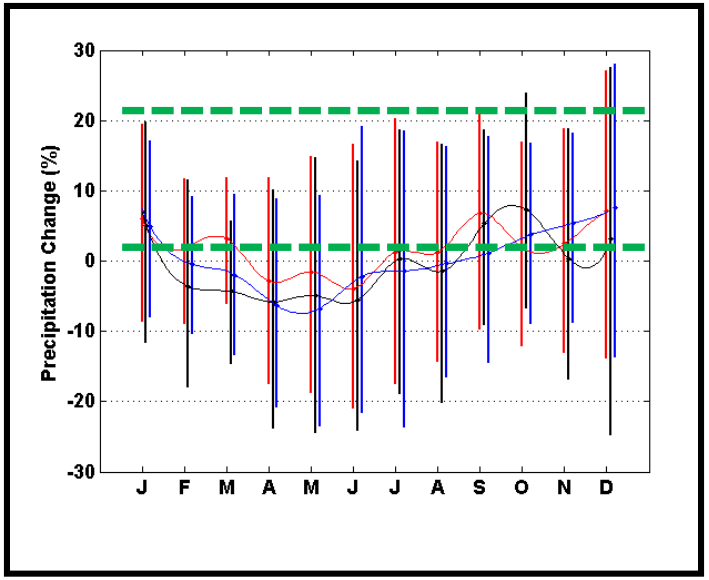
$\lambda_i \sim \Gamma(a,b)$, $\theta_i \sim \Gamma(c,d)$

- A Bayesian approach
- Reward models with respect to BIAS (w.r.t. current climate) and CONVERGENCE (consensus on future projections)
- 23 Models, SRES scenarios A2(high), A1B (midrange), B1(low)
- Posterior distribution of precipitation & temperature for each season & future decades

Projected Changes using AOGCMs (for 2050) – Posterior Distribution (CMIP3)

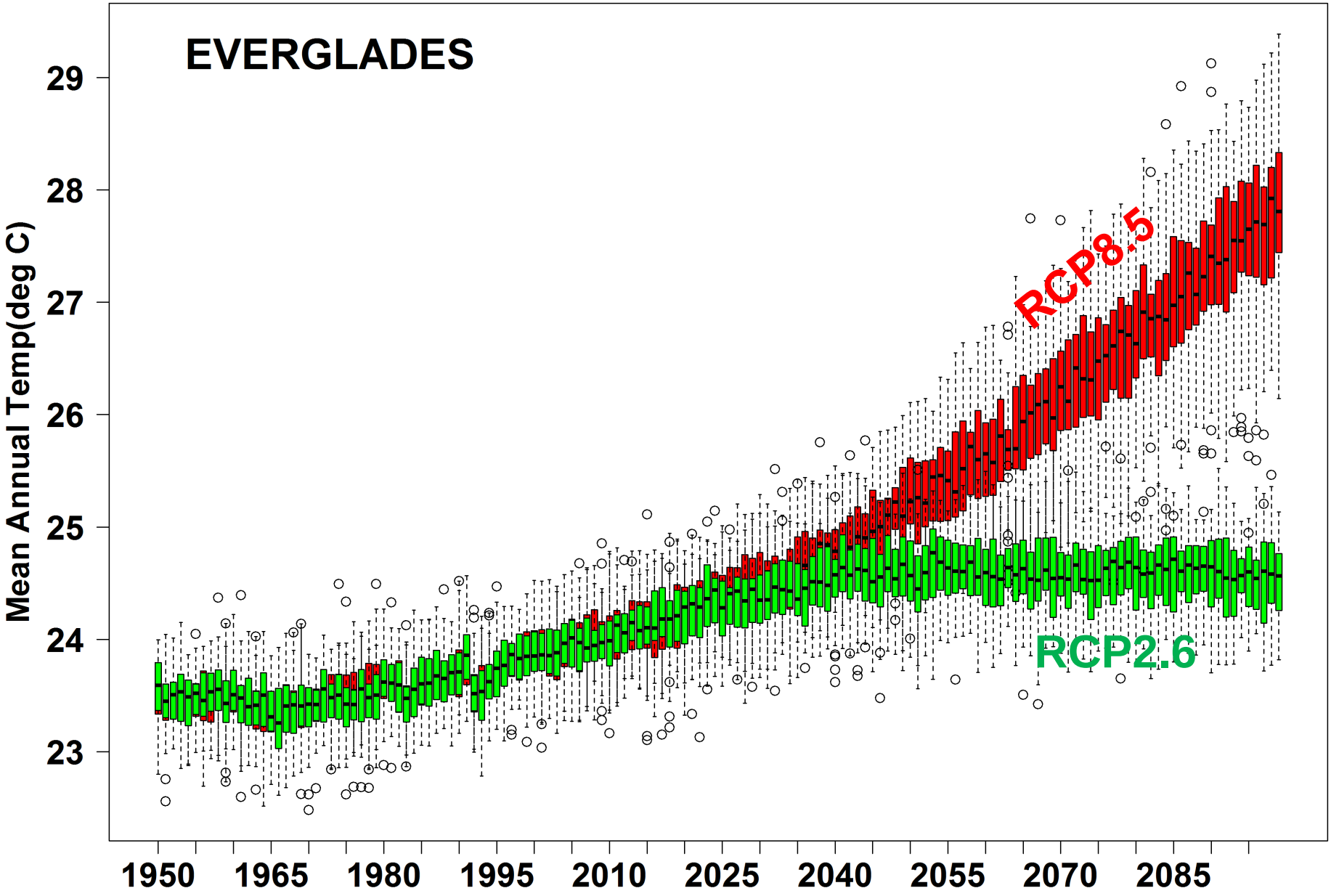


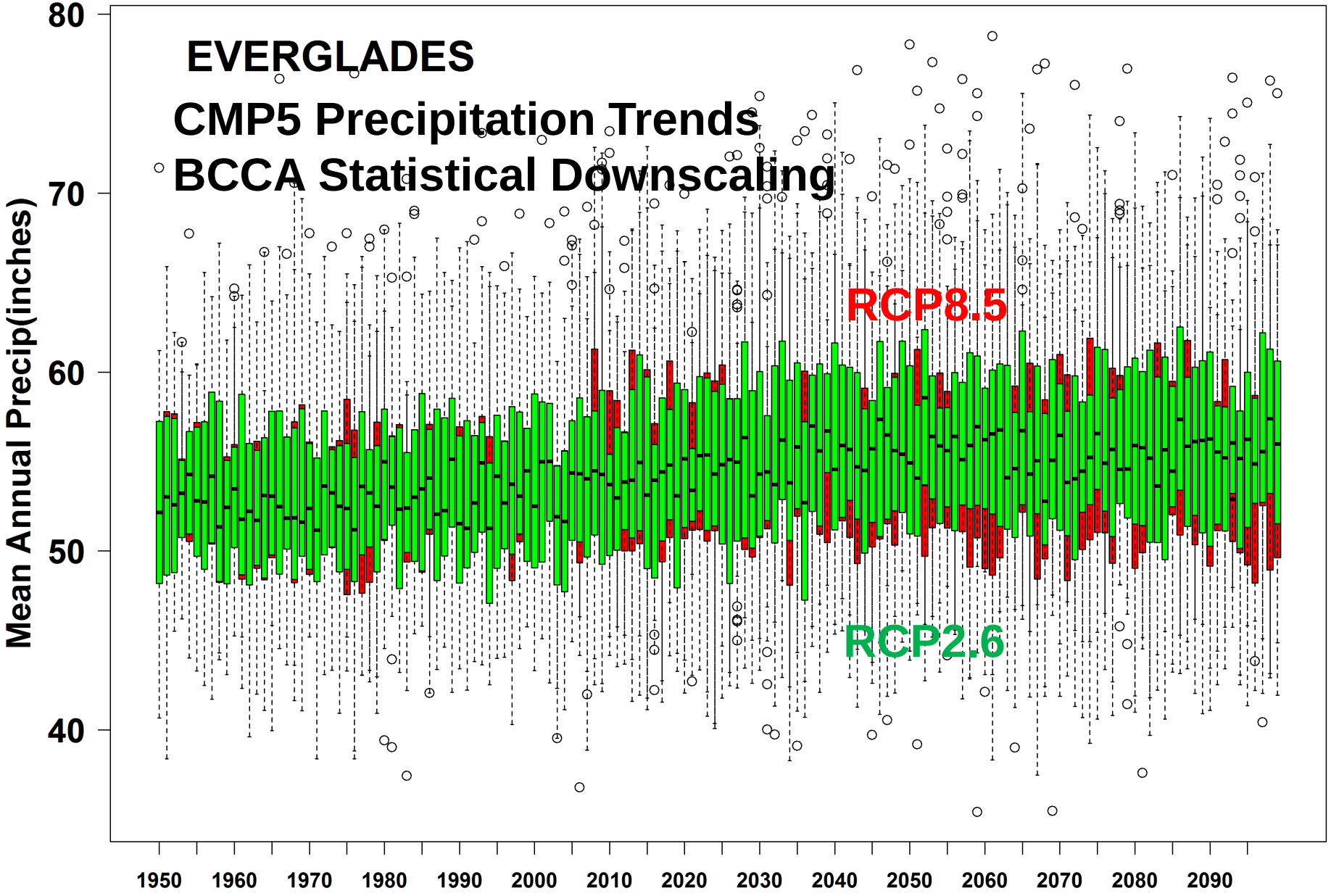




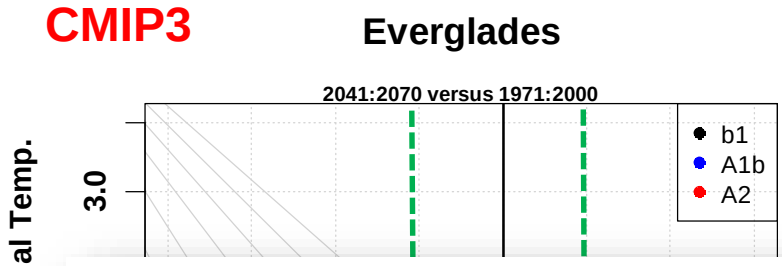
Downscaling CMIP3 & CMIP5 GCM Climate Projections

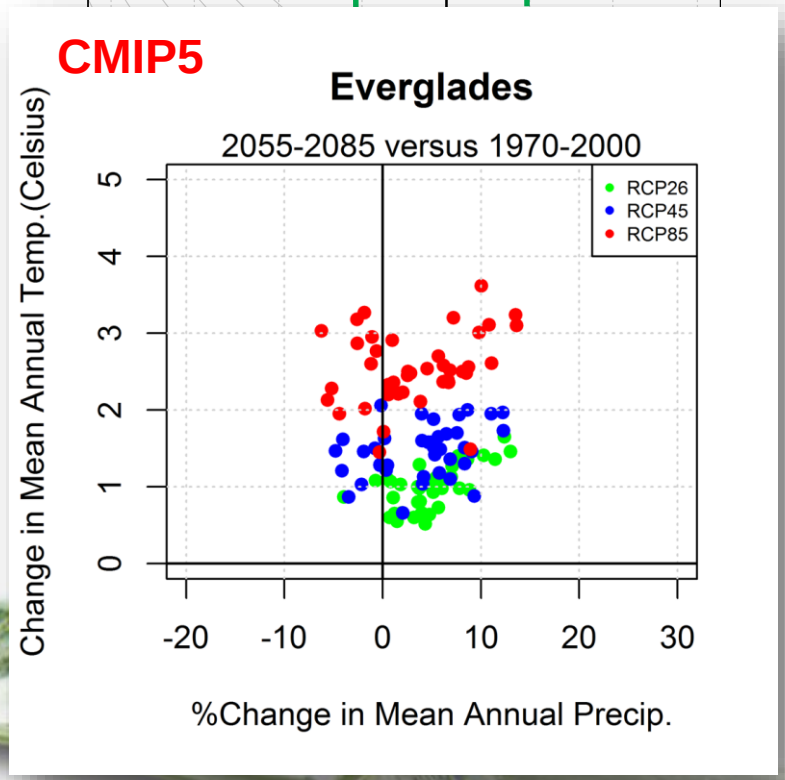
- **Statistical Downscaling** (~12 km)
  - BCSD (Bias-Corrected, Spatially-Downscaled)
  - BCCA (Bias-Corrected, Constructed Analogs)
  - LOCA (Not analyzed yet)
- **Dynamical Downscaling** (using Regional Climate Models)
  - NARCCAP (from NCAR) (~50km)
  - FSU – Regional Spectral Model (~10km) (Not used in our study yet but others have)

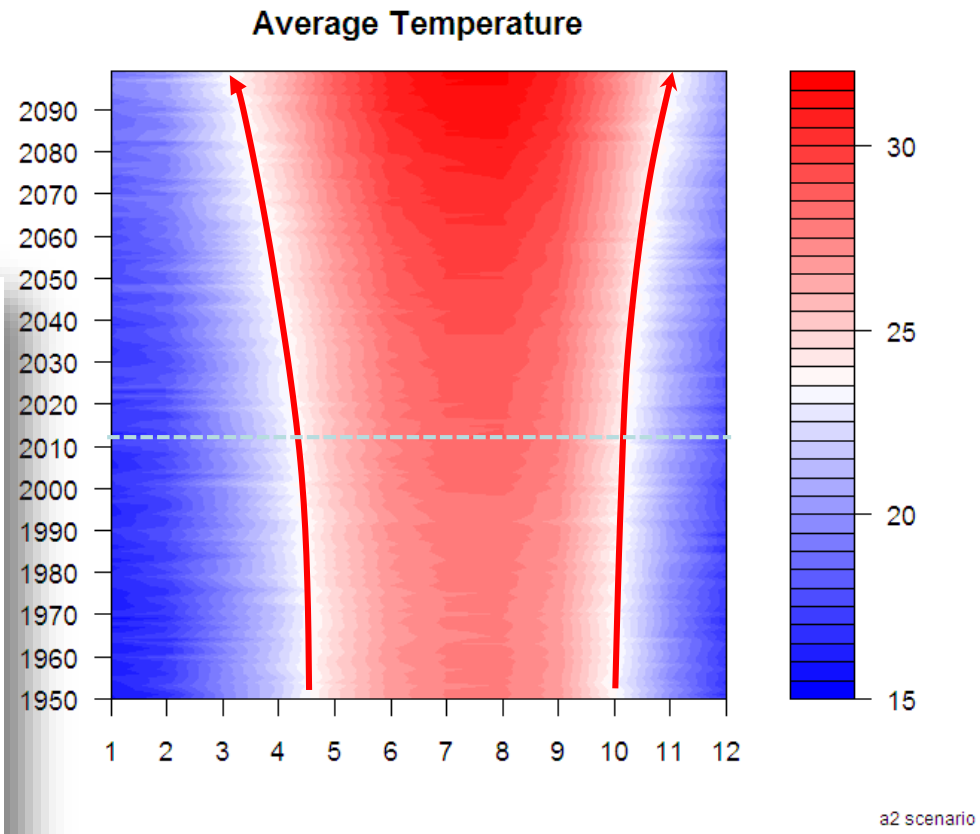

EVERGLADES
Mean Annual Temp(deg C)
29
28
27
26
25
24
23
1950
1965
1980
1995
2010
2025
2040
2055
2070
2085
RCP8.5
RCP2.6


EVERGLADES
CMP5 Precipitation Trends
BCCA Statistical Downscaling
RCP8.5
RCP2.6
Mean Annual Precip(inches)
80
70
60
50
40
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

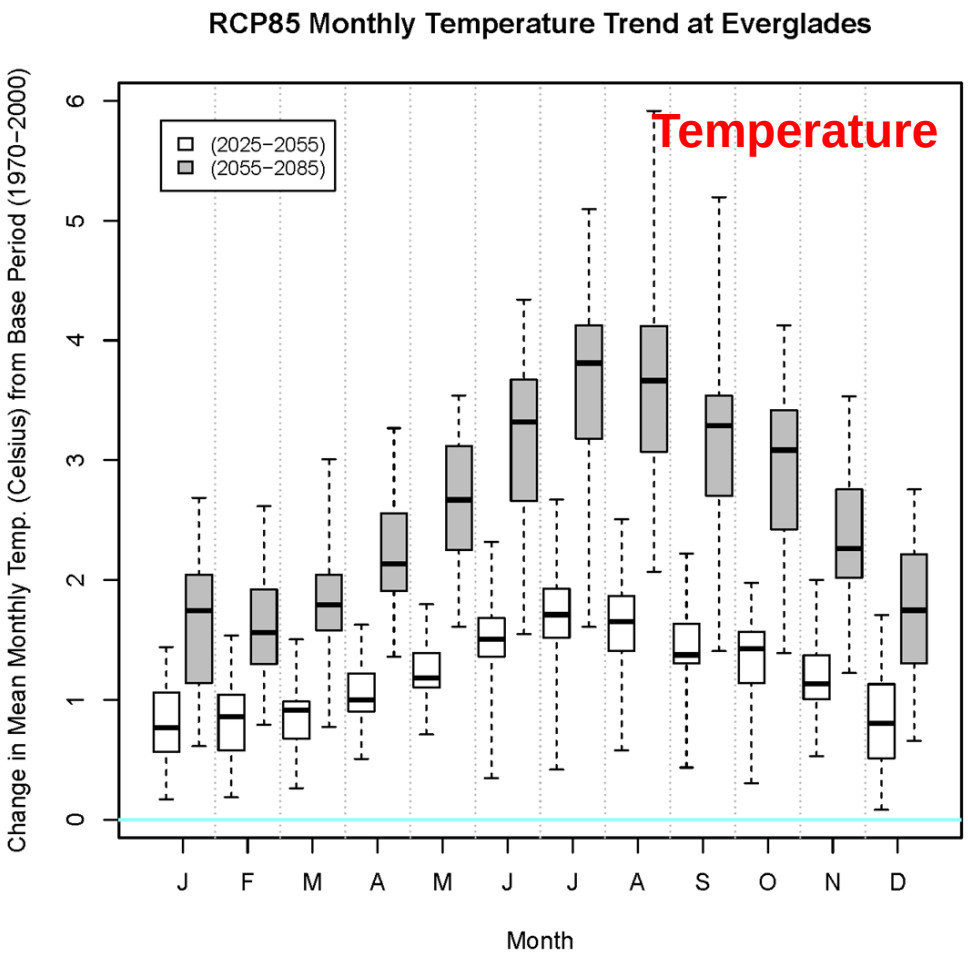
Change: Magnitude & Seasonality

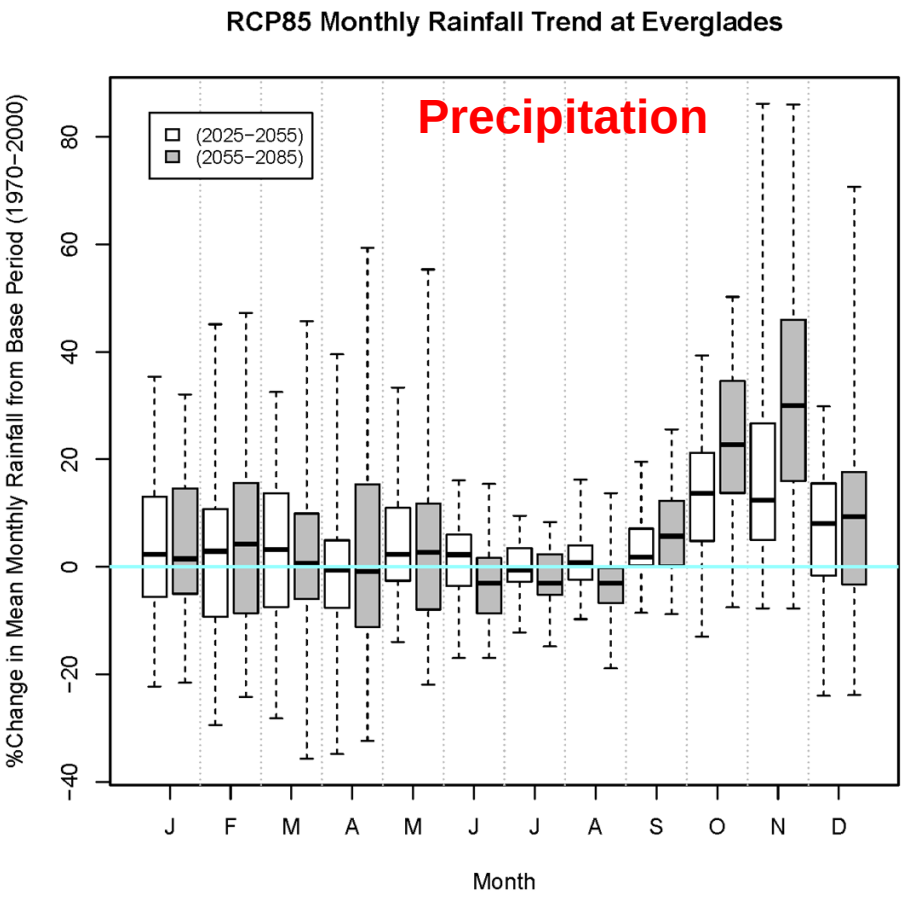




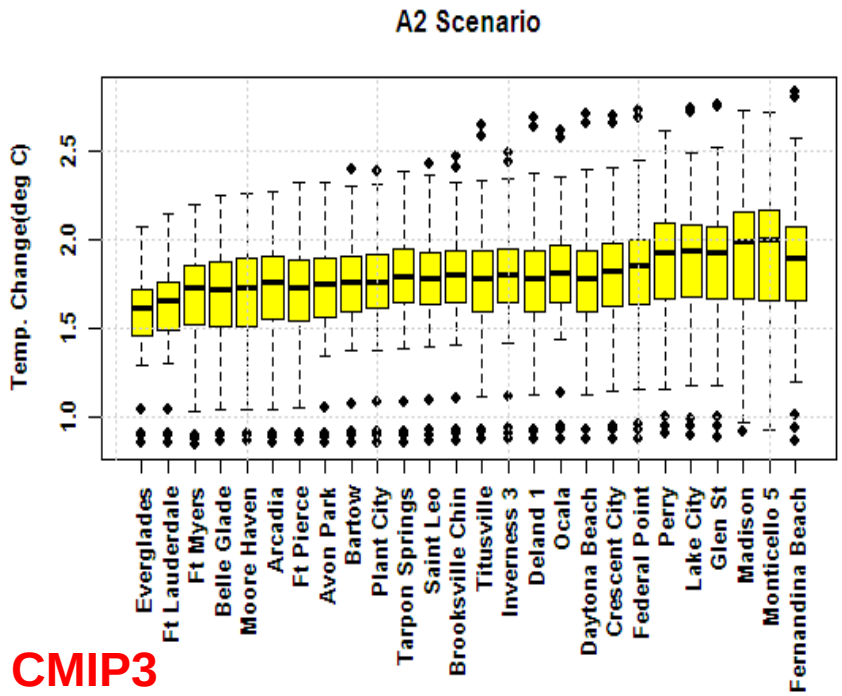


Changes to Seasonal Patterns (CMIP5)

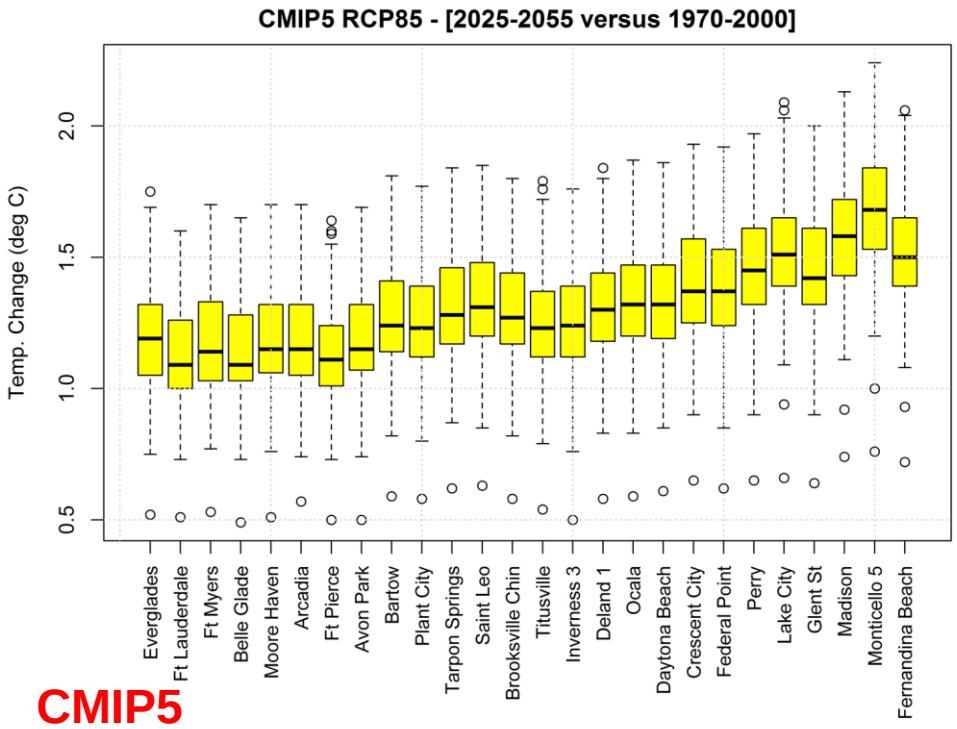




Spatial Trends in Florida

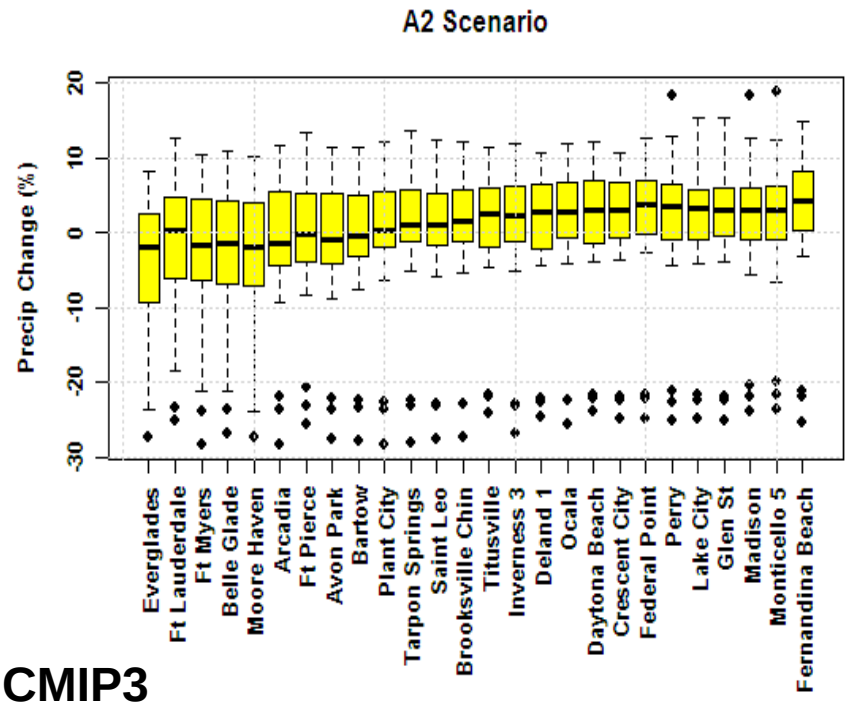


CMIP3

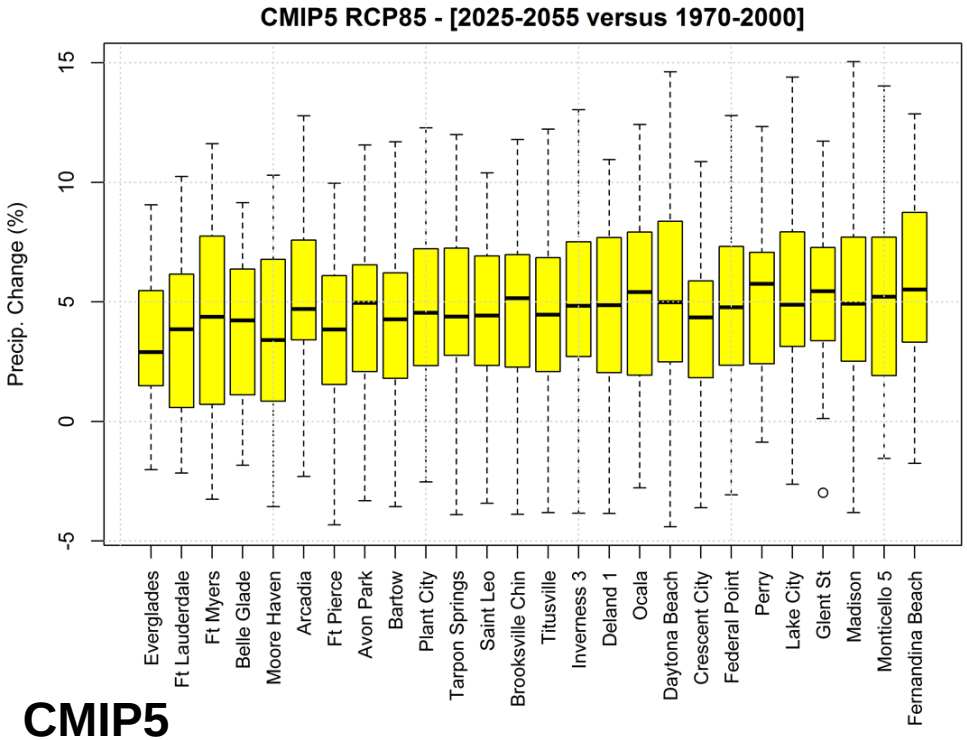


CMIP5

Spatial Trends in Florida (cont.) – Rainfall



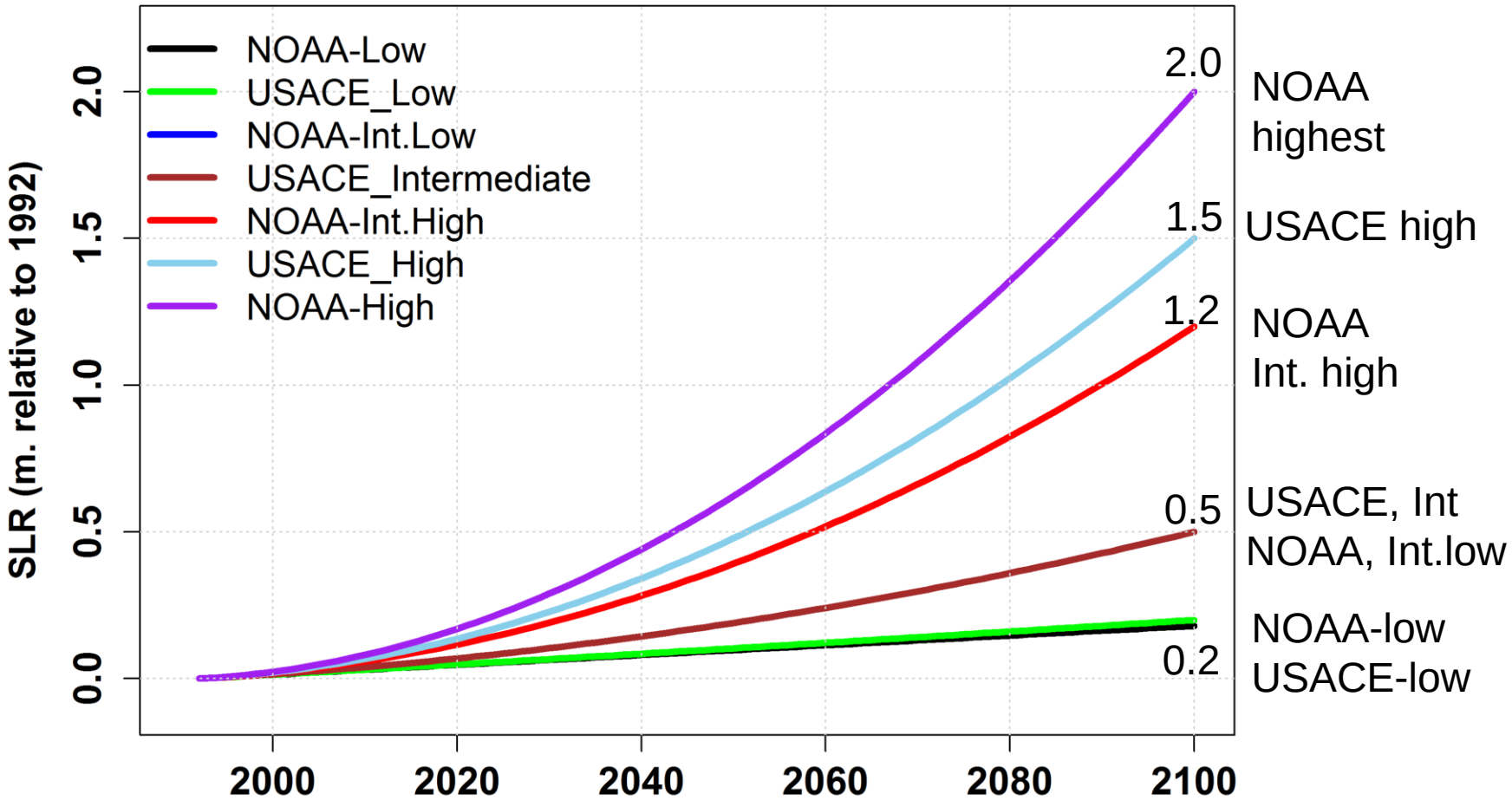
CMIP3



CMIP5

Sea Level Rise

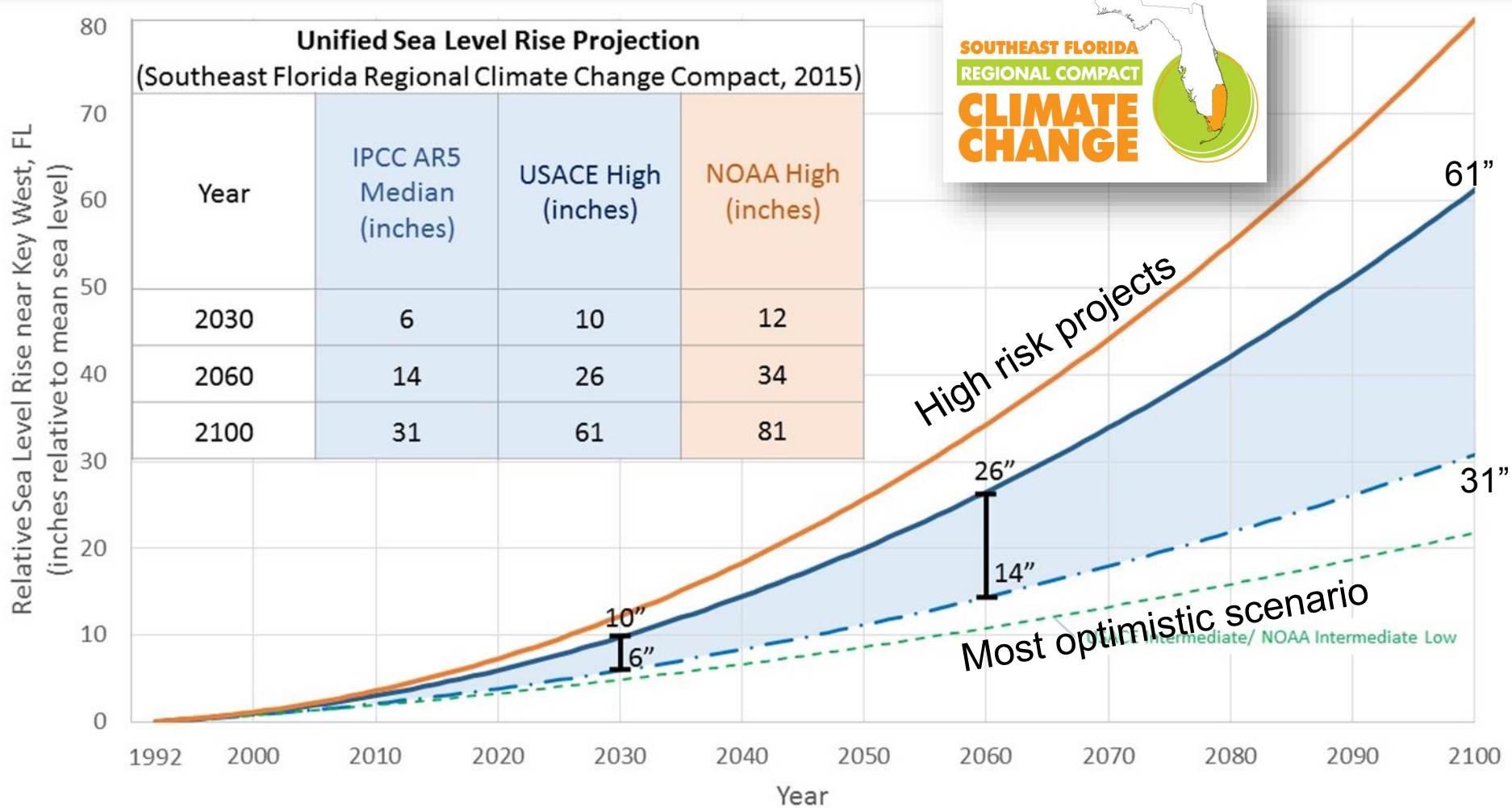
Comparison of GMSL Projections



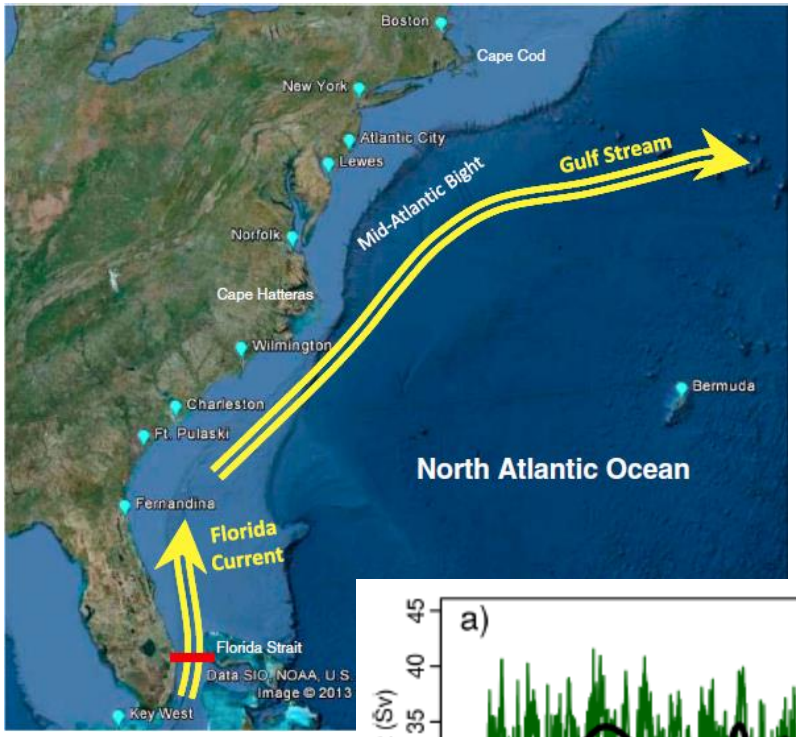
Latest Regional Sea Level Projections

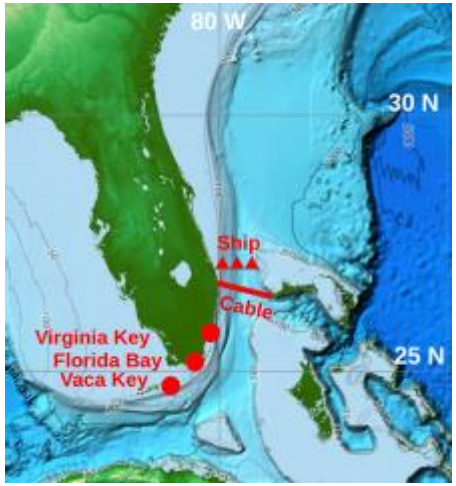
Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

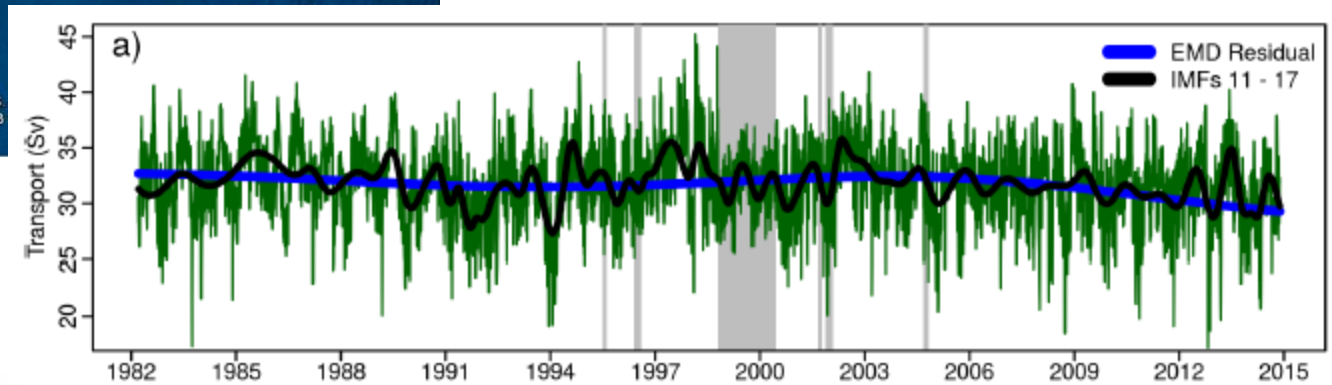
Year	IPCC AR5 Median (inches)	USACE High (inches)	NOAA High (inches)
2030	6	10	12
2060	14	26	34
2100	31	61	81



Decline in Florida Current Transport?

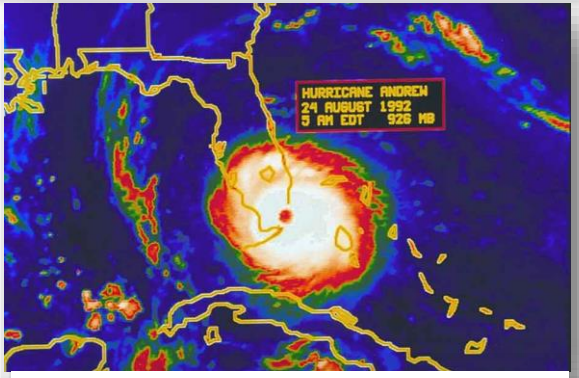


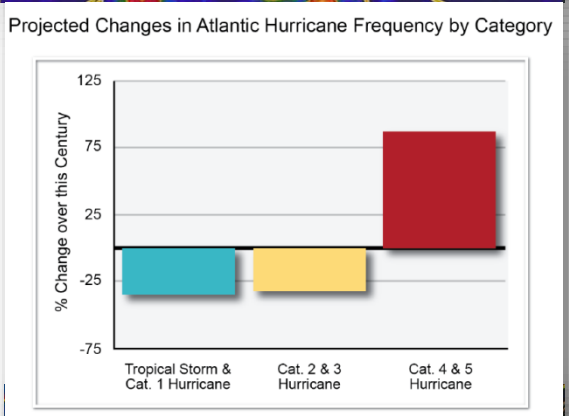


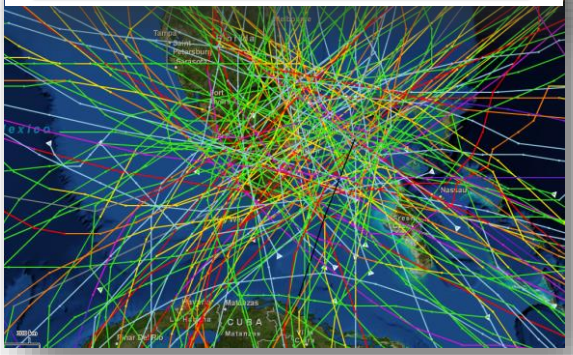


Tropical Storms & Climate Change

- Tropical cyclones to shift towards strong storms (2-11% intensity increase by 2100)
- Decrease in global frequency of tropical cyclones (6-34%)-recent paper says this will increase!
- Increase in the frequency of the most intense cyclones
- Increase in rainfall rate, 20% within 100 km of storm center

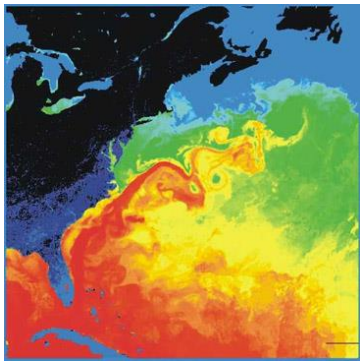




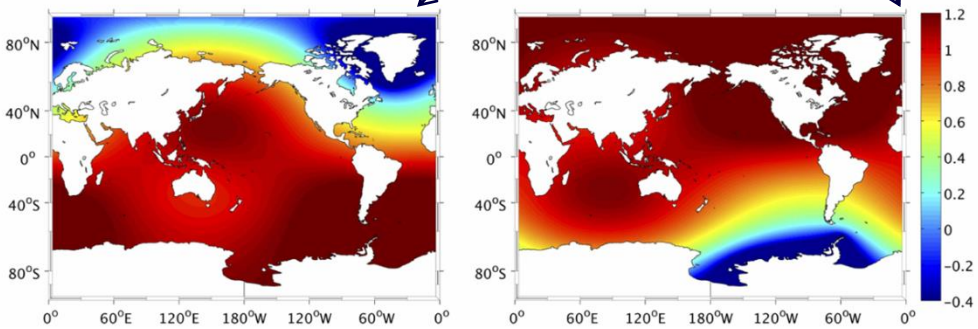


Need better information to regionalize sea level rise projections

- Land subsidence or uplift, Post Glacial Rebound
- Ocean Dynamics (e.g. Gulf stream)
- Gravitational and rotational effects of land ice redistribution (more complex)



Ice melt effect
- Greenland
- Antarctica



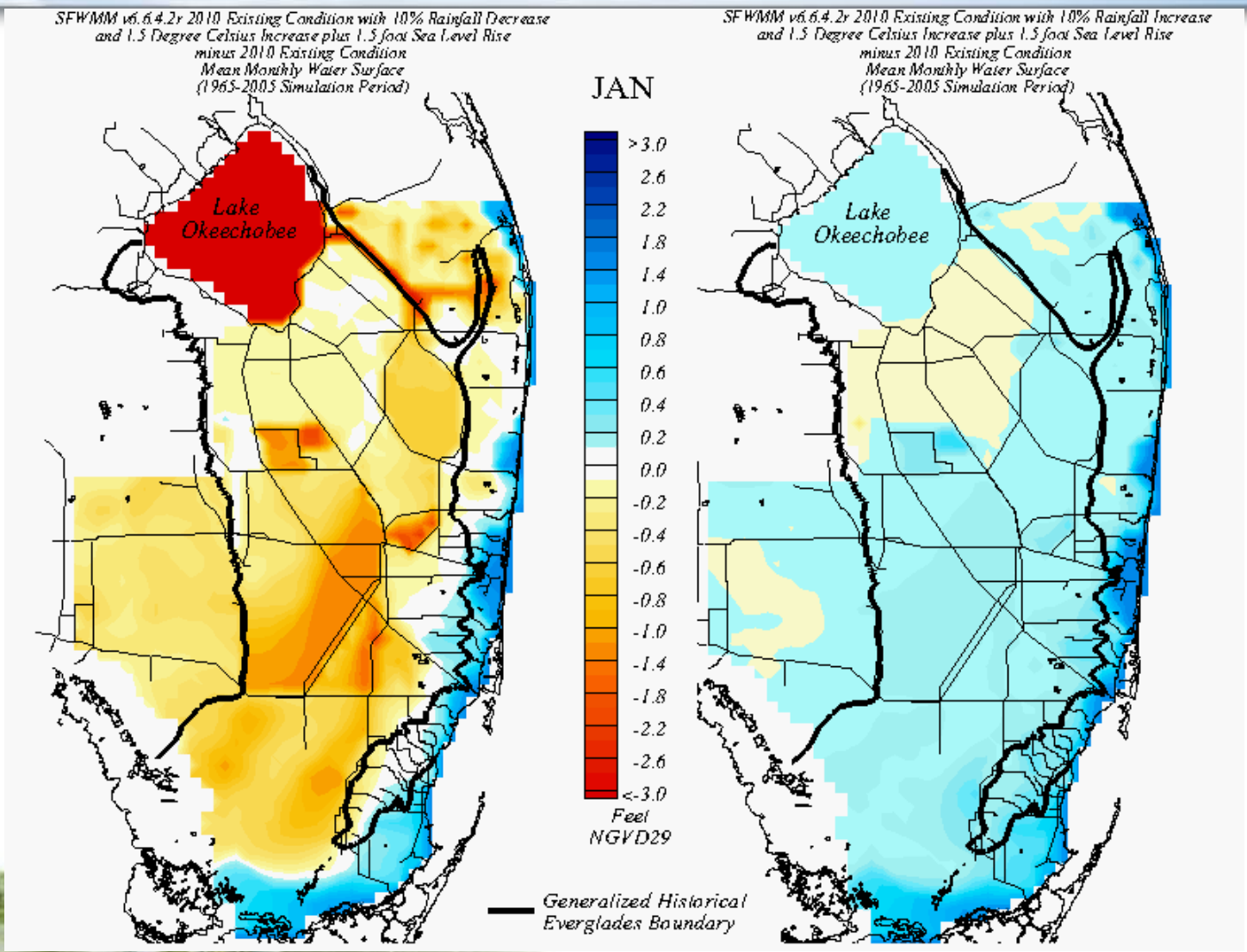
Scenario Assumptions for 2060

Variable	Global Models	Statistically Downscaled Data	Dynamically Downscaled Data
Average Temperature	1 to 1.5ºC	1 to 2ºC	1.8 to 2.1ºC
Precipitation	-10% to +10%	-5% to +5%	-3 to 2 inches
Sea Level Rise	1.5 feet		

Modeling Scenarios

- 2010 Baseline (demands and landuse corresponding to 2010 simulated with the 1965-2005 rainfall & ET (**BASE**)
- 2010 Baseline with 10% decrease in rainfall (**decRF**)
- 2010 Baseline with 10% increase in rainfall (**incRF**)
- 2010 Baseline with 1.5° Celsius increase and 1.5 foot sea level rise with increased coastal canal levels (**incET**)
- 2010 Baseline with 10% decrease in rainfall, 1.5° Celsius increase and 1.5 foot sea level rise with increased coastal canal levels (**decRFincET**)
- 2010 Baseline with 10% decrease in rainfall, 1.5° Celsius increase and 1.5 foot sea level rise with <u>no increased coastal canal levels</u> (**decRFincETnoC**)
- 2010 Baseline with 10% increase in rainfall, 1.5° Celsius increase and 1.5 foot sea level rise with increased coastal canal levels (**incRFincET**)

DecRFincET versus IncRFincET



Possible Next Steps

- 119 daily rainfall and ET datasets in 2x2 format are available. Tidal predictions at numerous locations along the coast are also available.
- Extend the 2x2 model to 2016?
- Run the scenarios using 2x2 (by Interagency Modeling Center?)
- Investigate both the LOCA and FSU dynamically downscaled dataset for skills