

THE USE OF DOWN-SCALED CLIMATE DATA IN WATER RESOURCES AND RESILIENCY PLANNING IN SOUTHEAST FLORIDA

Aspen High-Resolution
Modeling and Data Workshop
August 2-7, 2015



GEOGRAPHIC LOCATION

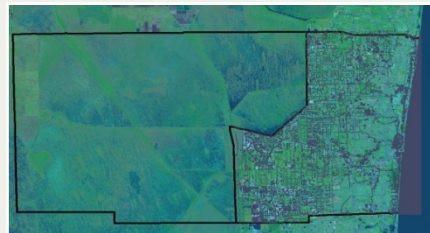
Southeast Florida



Characteristics:

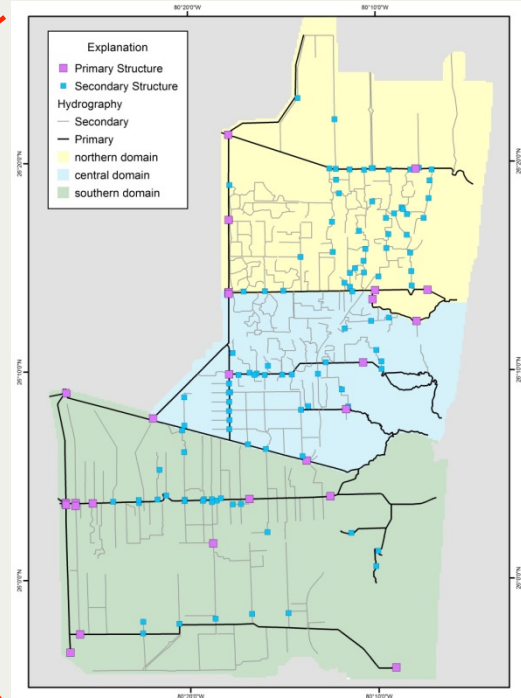
- Flat, low-lying
- Porous geology
- Coastal development
- Complex water mgmt system

Everglades Watershed



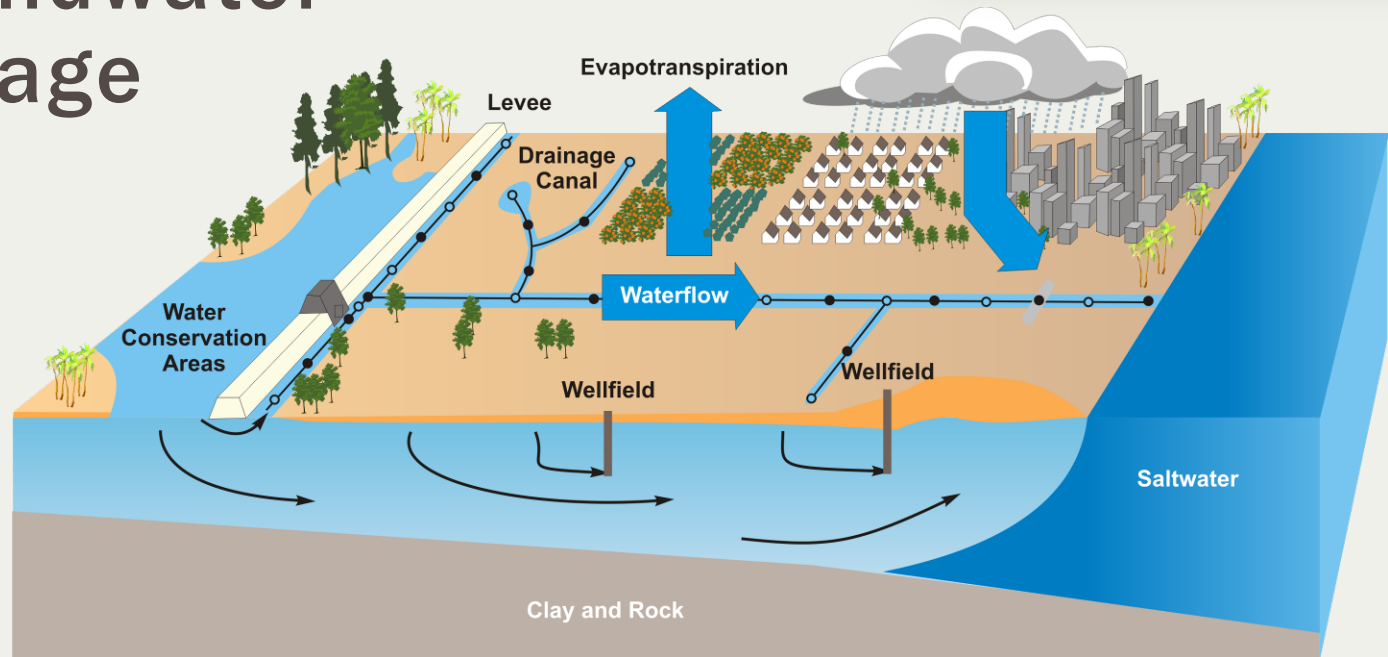
Broward County

Urban Broward County



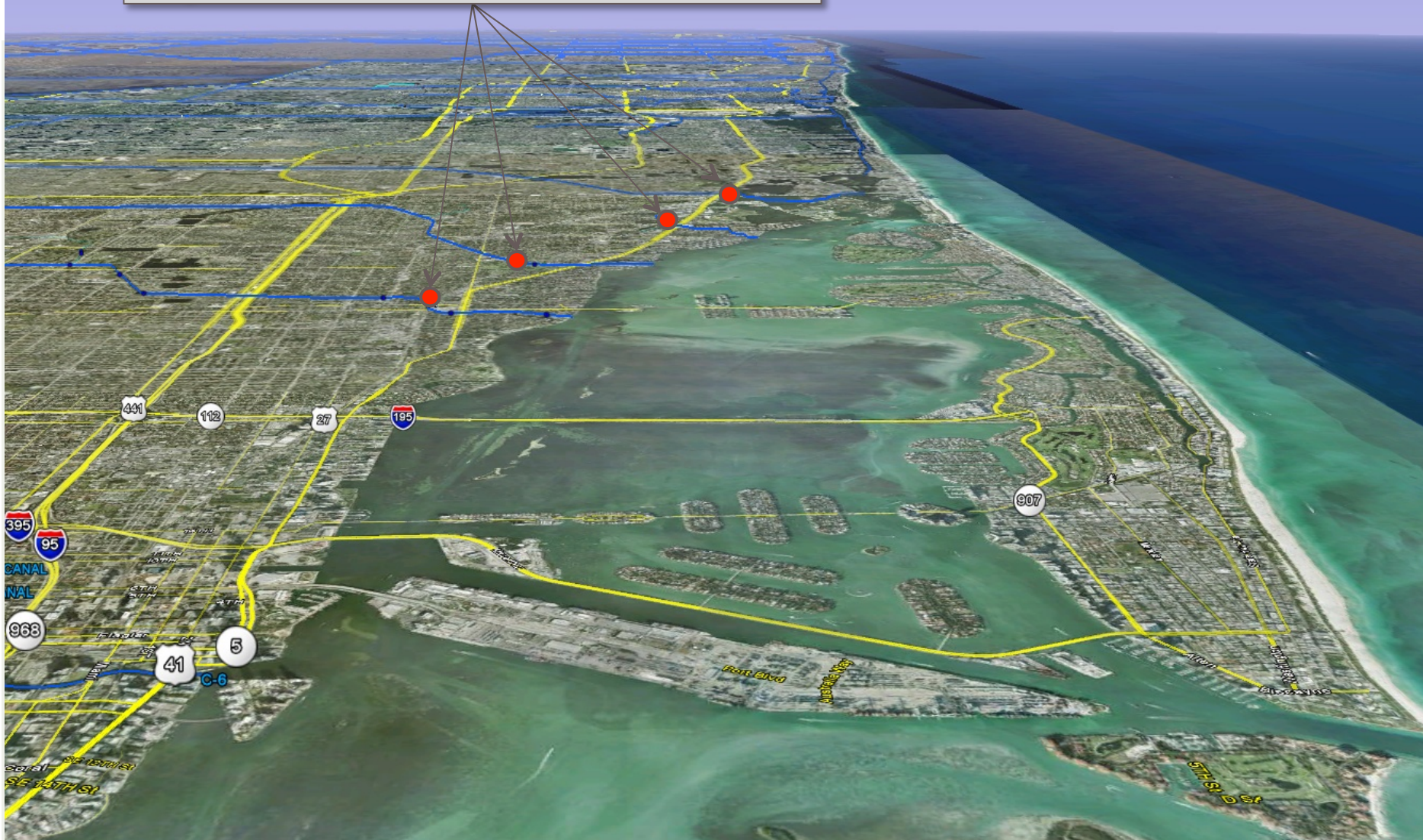
REGIONAL HYDROLOGY

- Rainfall
- Surface deliveries
- Groundwater seepage



REGIONAL WATER CONTROL SYSTEM

Regional Coastal Water Control Structures



REGIONAL WATER RESOURCE MANAGEMENT AND PLANNING

- Water supply
- Stormwater management
- Coastal/tidal flooding
- Everglades restoration

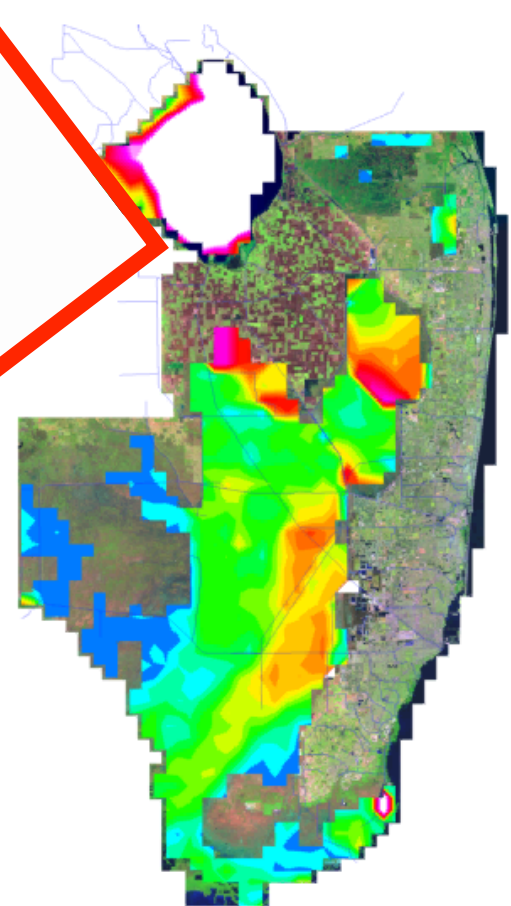
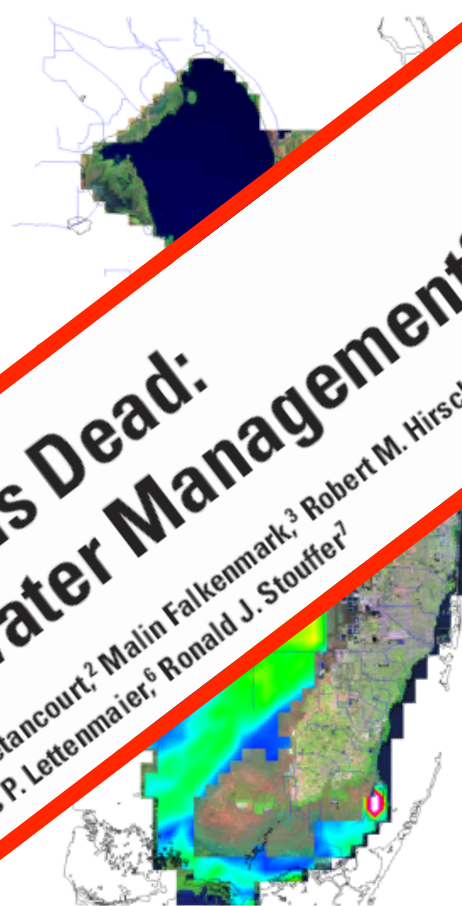
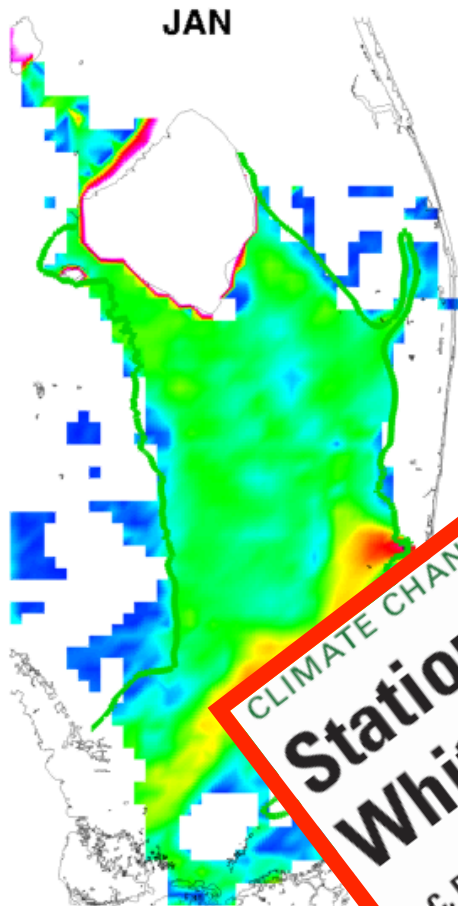


WATER RESOURCE PLANNING – DO WE NEED A NEW PARADIGM?

Natural System

Managed System

CERP

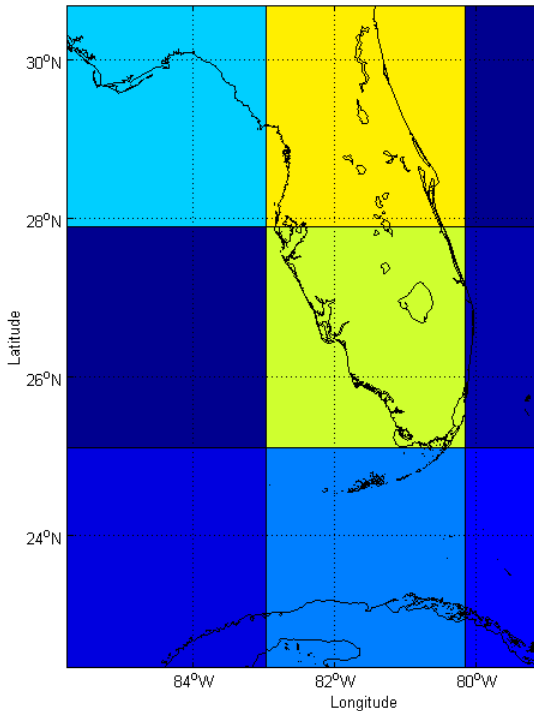


CLIMATE CHANGE
**Stationarity Is Dead:
Whither Water Management?**

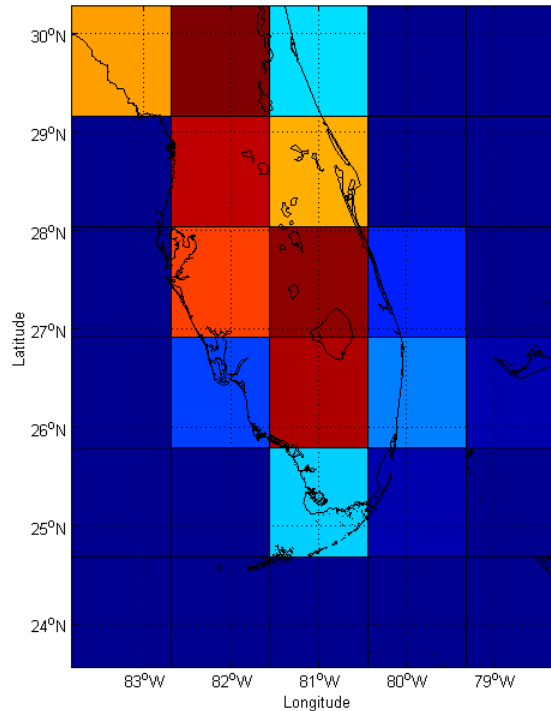
P. C. D. Milly,^{1*} Julio Betancourt,² Malin Falkenmark,³ Robert M. Hirsch,⁴ Zbigniew W. Kundzewicz,⁵ Dennis P. Lettenmaier,⁶ Ronald J. Stouffer⁷

GCM RESOLUTION IN FLORIDA

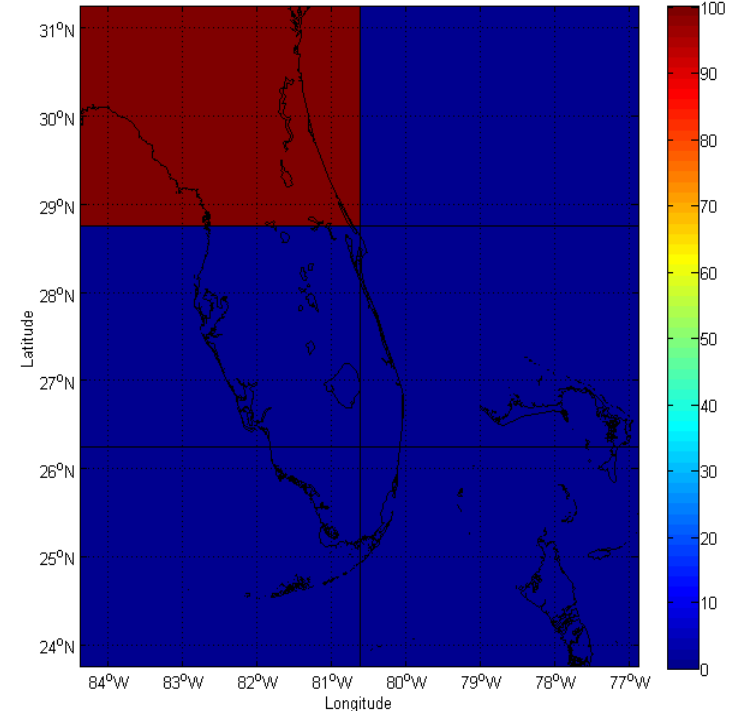
Land-sea mask for BCM2



Land-sea mask for MIHR



Land-sea mask for HADCM3



Uncertainties in GCM predictions due to:

- **Poor resolution – South Florida not even modeled in some GCMs; greater errors at smaller scales**

CLIMATE PROJECTION UNCERTAINTIES

Natural Variability

General Circulation Model

GCM
(IPCC,
2007)

BCM2
CGHR
CGMR
CNCM3
CSMK3
ECHOC
FGCM2.3.5
FGCM20
GFCM21
GIAOM
INCM3
IPCM4
MIHR
MIMR
MPEH5
NCCCSM
NCPCM

Downscaling

Statistical
Dynamical

- Constructed Analogues (CA)
- Bias Correction and Spatial Downscaling (BCSD)
- Weather Generators

Regional Climate Models (RCMs)

Ice Sheet Dynamics

Scenarios

B1	A1T	B2	A1B	A2	A1FI
1.1-2.9 (°C)	1.4-3.8 (°C)	1.4-3.8 (°C)	1.4-3.8 (°C)	2.0-5.4 (°C)	2.4-6.4 (°C)
0.18-0.38 (m)	0.20-0.4 (m)	0.20-0.43 (m)	0.21-0.48 (m)	0.23-0.51 (m)	0.26-0.59 (m)

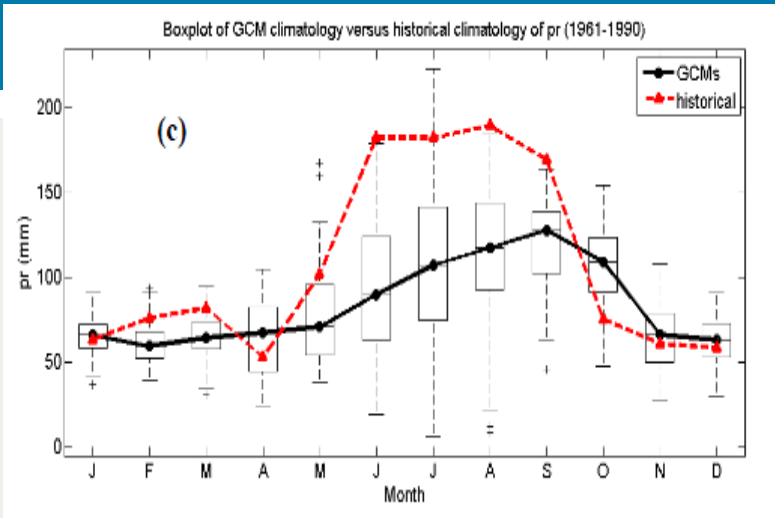
Climate Change
Implications in Water
Resources Investigations:

- Scenario based approaches
- Use all models
- Model Culling?

APPROACH: SOUTH FLORIDA WATER MANAGEMENT DISTRICT

- Downscaling of CMIP3 GCM Climate Projections
- Statistical Downscaling
 - BCSD (Bias-Corrected, Spatially-Downscaled)
 - BCCA (Bias-Corrected, Constructed Analogs)
 - Others are being developed
- Dynamical Downscaling (using Regional Climate Models)
 - NARCCAP (from NCAR)
 - FSU – Regional Spectral Model (RSM) (Not used in our study yet but others have)

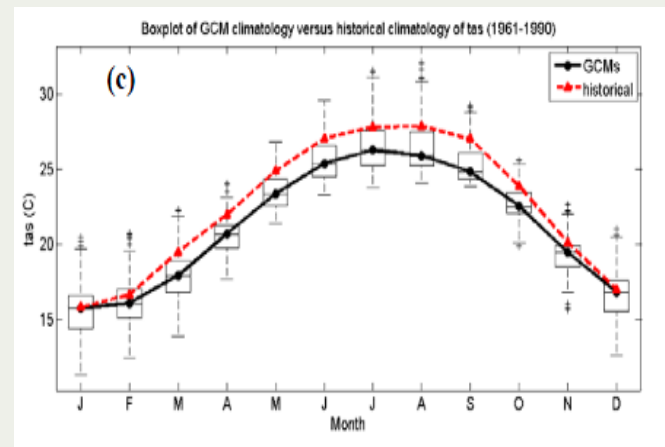
WHAT WE KNOW



Source: 2011 SFWMD Tech. Report,
Obeysekera et al

- Can have significant errors in precipitation due to inability to model the convective storms, and sea breeze
- Coarseness of GCMs leads to need for down-scaled regional climate data

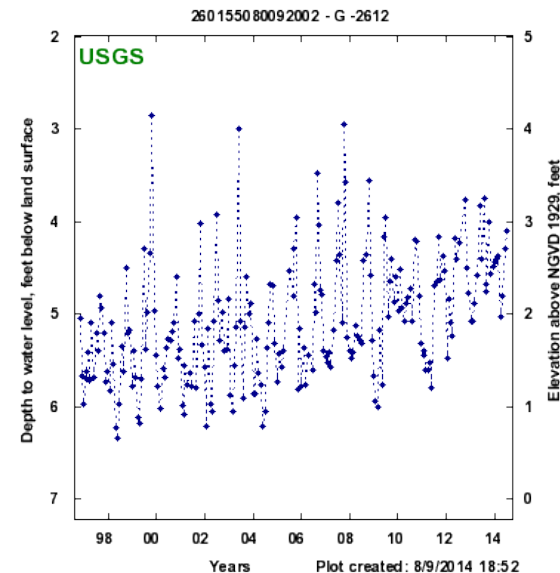
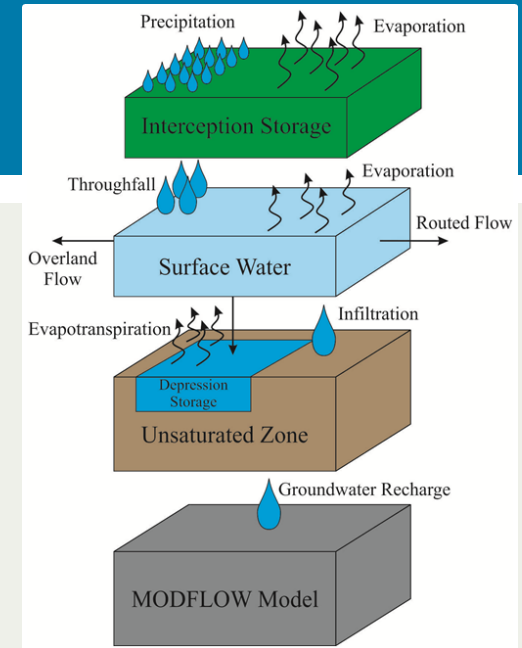
- GCMs are typically better predictors of temperature than precipitation and averages vs. absolutes
- Difficulty predicting ET rates



Source: 2011SFMD Tech. Report,
Obeysekera et al

SIGNIFICANT IMPLICATIONS FOR SE FLORIDA

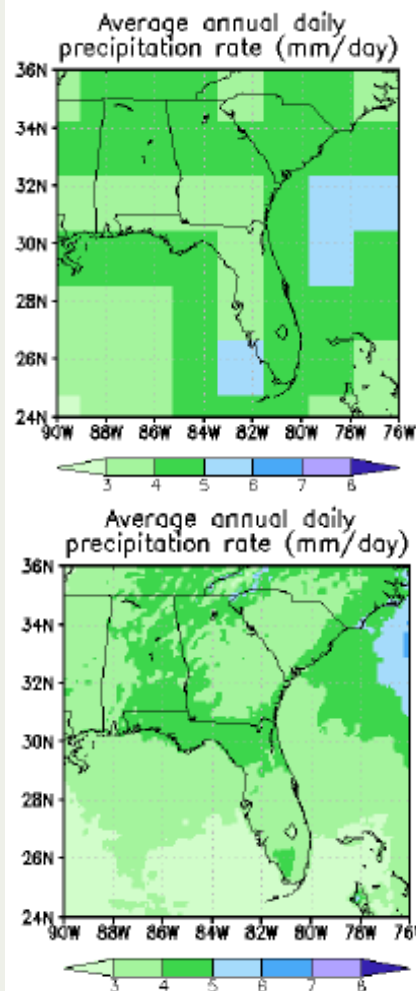
- Historically, rainfall events <3" account for majority of annual rainfall
- ET is a major influence on regional hydrologic processes
- Assumptions affect modeled results for:
 - Aquifer recharge
 - Water quality/chlorides
 - Water supply/availability
 - Drainage/flood management
 - Ecosystems



DOWN-SCALING TO SUPPORT LOCAL PLANNING

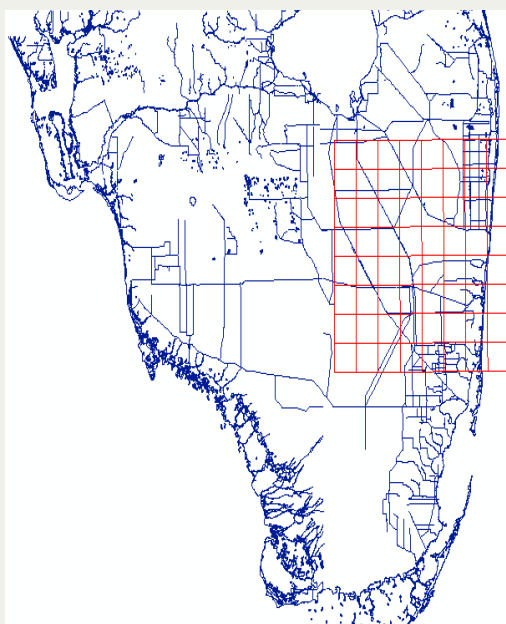


Example Resolution of RCM:



Source: Stefanova et al., 2011

*RCM cells covering
urban model area*

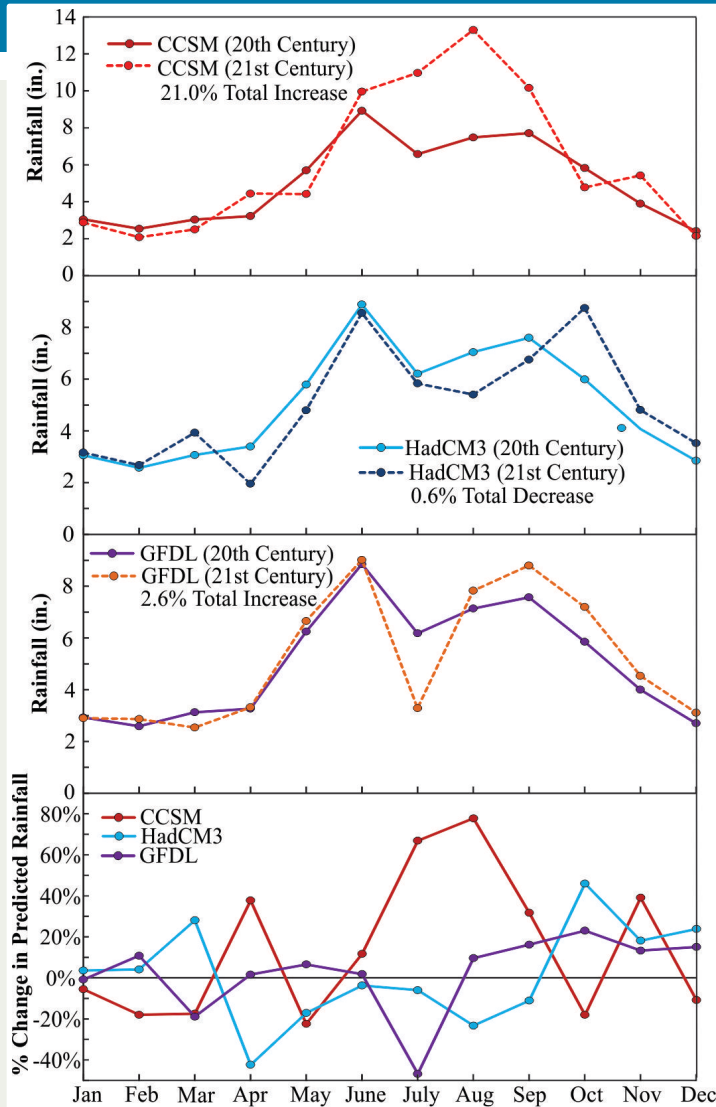


Downscaled Reanalysis
Results

Dynamically Downscaled GCM Results

- Center for Ocean-Atmospheric Studies (COAPS)
- RCM coupled to 3 different GCM's (CCSM, HadCM3, GFDL)
- Daily, bias-corrected output
- Uses FSU-FCI Regional Spectral Model
- Still, may not fully represent localized climate accurately even at 10 km scale

ANALYSIS OF FUTURE SCENARIOS



Average Monthly Rainfall (1968-2000)

Month	CCSM	HadCM3	GFDL
January	3.043	3.055	2.929
February	2.538	2.572	2.588
March	3.035	3.068	3.131
April	3.225	3.395	3.266
May	5.696	5.790	6.246
June	8.923	8.885	8.855
July	6.576	6.206	6.180
August	7.480	7.044	7.140
September	7.713	7.597	7.573
October	5.825	5.993	5.854
November	3.902	4.070	4.004
December	2.408	2.848	2.704
Yearly Total	60.364	60.522	60.472

Average Monthly Rainfall (2038-2069)

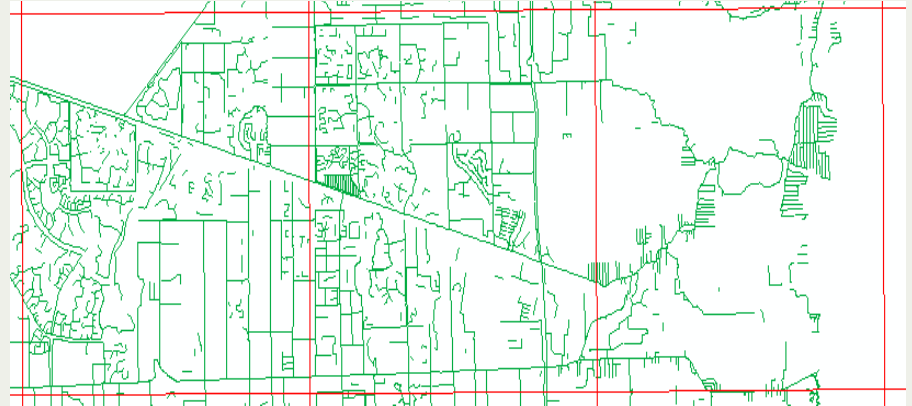
Month	CCSM	HadCM3	GFDL
January	2.875	3.164	2.905
February	2.082	2.677	2.868
March	2.505	3.930	2.540
April	4.443	1.957	3.319
May	4.418	4.798	6.656
June	9.964	8.555	9.018
July	10.974	5.834	3.288
August	13.297	5.405	7.828
September	10.162	6.756	8.801
October	4.775	8.750	7.201
November	5.426	4.809	4.537
December	2.148	3.527	3.112
Yearly Total	73.068	60.161	62.073

CAPTURING KEY STORMS

Climate Model Grid



16" rainfall event – December 2009



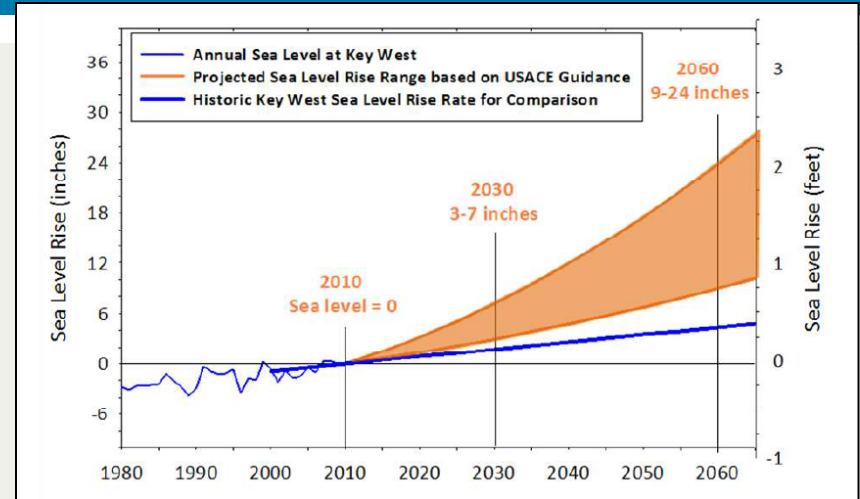
Telescoped model area

- Looking for high rainfall events in COAPS data
- Sum of all three climate cells
 - CCSM 20th – 12.9" (11/17/1992), 9.7" (12/10/1996)
 - CCSM 21st – 32.3" (4/4/2066), 19.6" (8/21/2062), 15.3" (8/22/2062)
 - HadCM3 20th – 15.9" (11/4/1997), 10.8" (6/5/1993)
 - HadCM3 21st – 17.8" (3/30/2068), 15.5" (11/23/2065)

DEVELOPMENT OF FUTURE SLR SCENARIOS

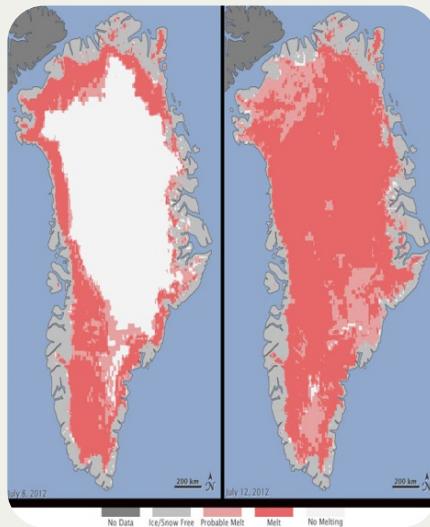
From “A Unified Sea Level Rise Projection for Southeast Florida” by Southeast Florida Regional Climate Change Compact Counties

- Future scenarios incorporate various predictions of sea level rise (SLR)
- Affects groundwater levels, water quality and discharge to coastal waters
- Additional challenges with combined storms and high-high tide
- Scenarios informed by Climate Change Compact guidance

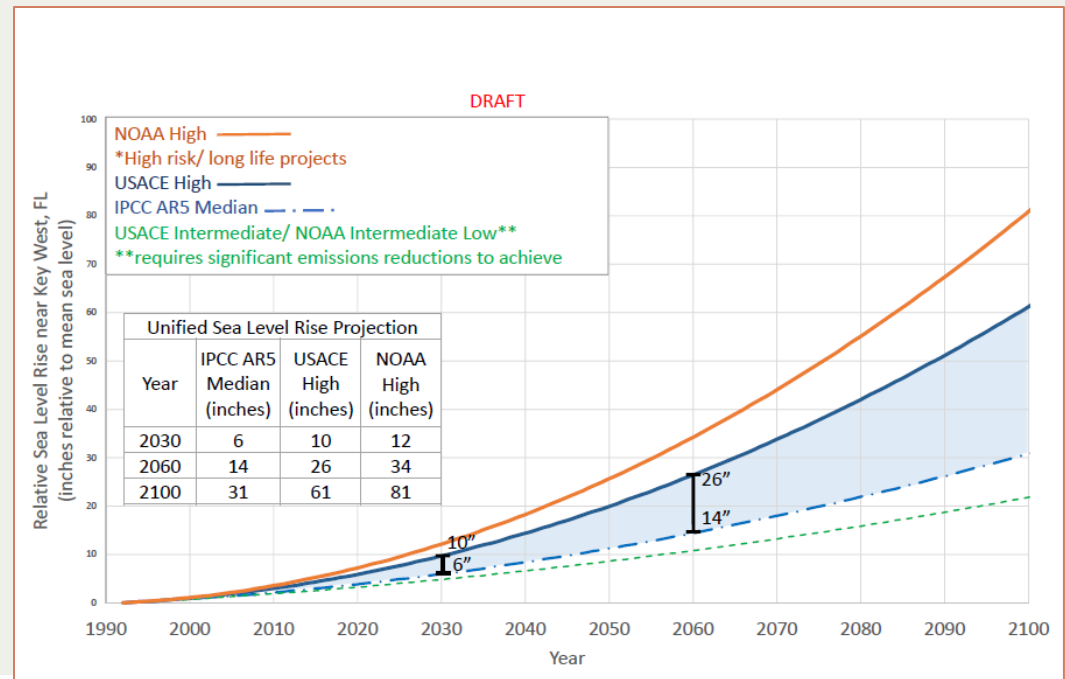


2015 REFINEMENTS

- 2015 Update to the Compact's Unified Sea Level Rise Projection with recognition of:
 - Availability of new science
 - Acceleration of ice melt in Greenland and Antarctic
 - Potential for slowing of gulf stream (not accounted for in IPCC)
 - Extension to 2100

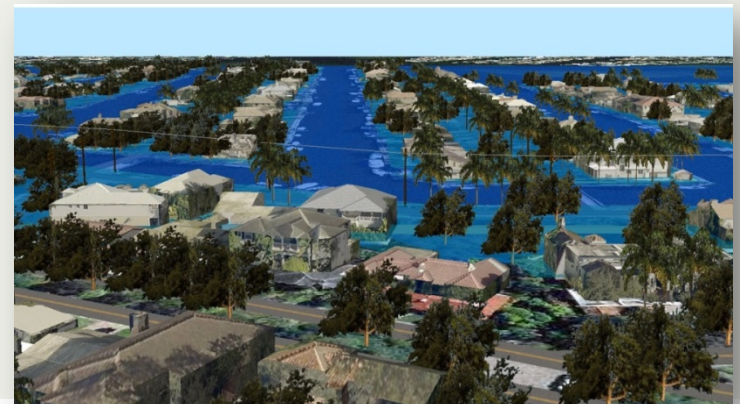
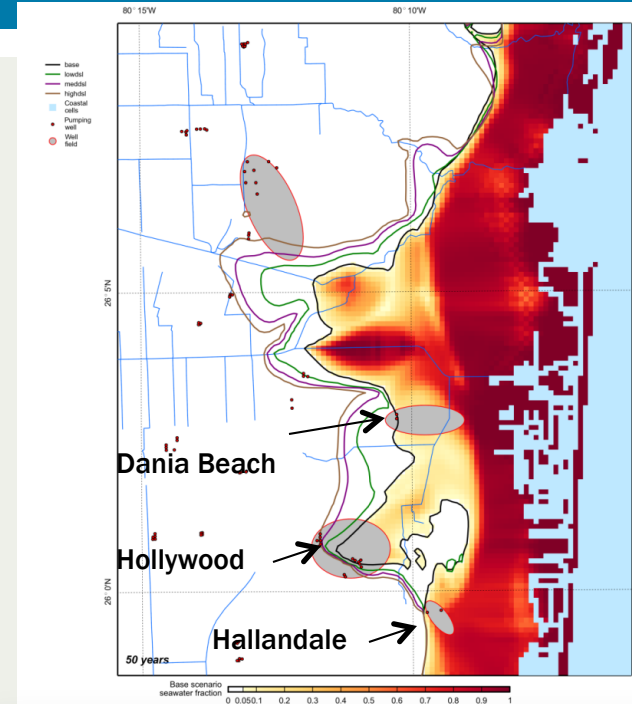


Nasa.gov

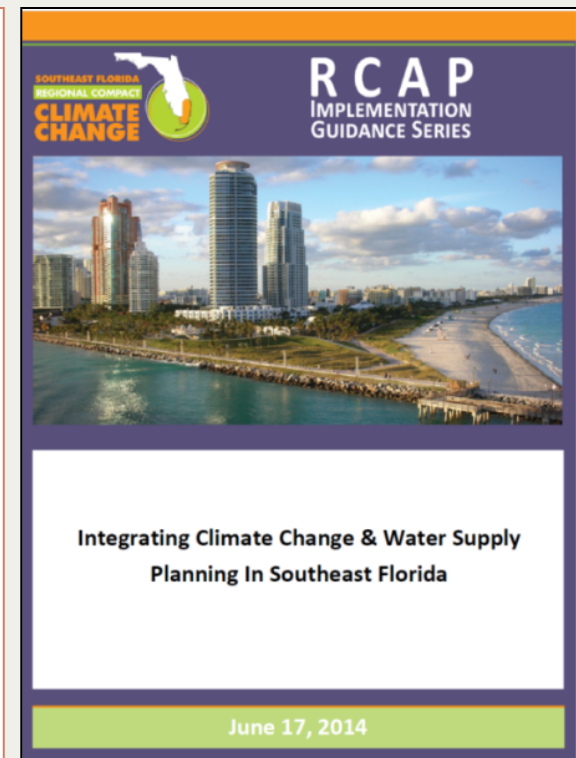
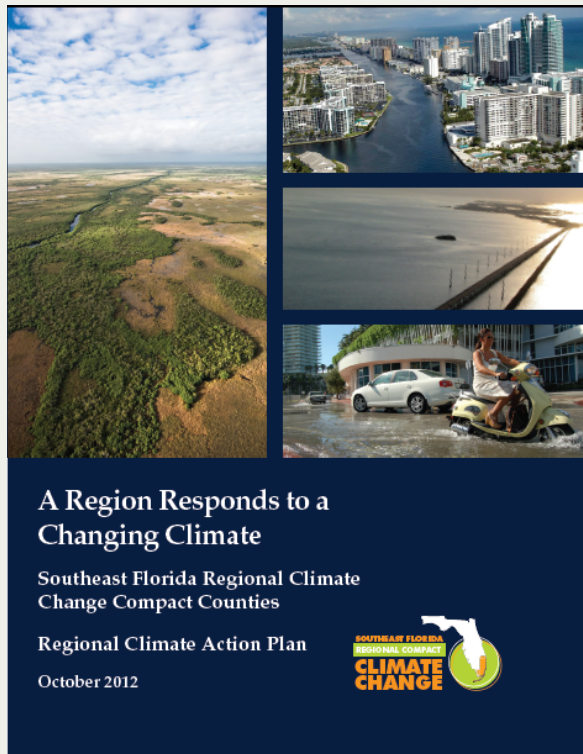


MODEL APPLICATION

- Saltwater intrusion and water supply impacts
- Stormwater inundation
- Wet/dry season groundwater elevations
- Testing of adaptation strategies
- Communications: Coupled with 3D visualization tools
- Refined vulnerability assessments
- Enhanced economic evaluations



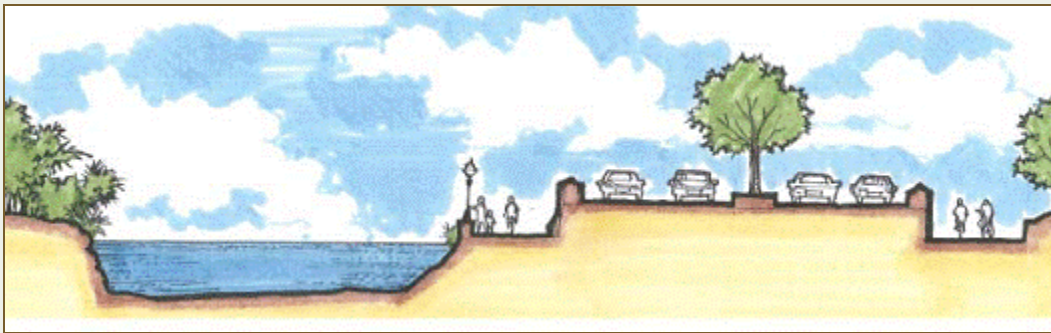
ADVANCING POLICY AND PLANNING



INFLUENCING PROJECTS



EMBEDDED IN RESILIENT REDESIGN



Kingdom of the Netherlands



AIA Miami
A Chapter of The American Institute of Architects



MIAMI CENTER FOR ARCHITECTURE & DESIGN

REGIONAL DOWN-SCALING DIALOG

- Down-scaling workshop held 6/22-23/15
- Attended by climate scientists, agency staff, resource managers
- Skills of models for regional climate information may not be adequate, yet. More work is need to verify and improve the methods/models.
- Critical hydrologic parameters:
 - Precipitation and evapotranspiration
 - 50-100 year projections
 - 24-hour data (extremes)



GENERAL ASSESSMENT

- Resolution of GCMs is not adequate to capture hydro-meteorology of Florida peninsula
 - Inability to represent convective precipitation and important features such as sea breeze and cloud cover
 - Florida current and Gulf Stream are over-looked in IPCC SLR projections.
 - How do we account for ocean dynamics and gravitational changes due to ice melt
- Lack adequate modeling of ocean boundary: storm surge under sea level rise scenarios

SUMMARY OF NEEDS

- Reliable projections of both long term rainfall patterns, natural variability, and extreme rainfall are needed
- Reliable projections of the frequency and magnitude of tropical storms/hurricanes
- Uniform procedures for calculating uncertainty
- Centralized portal for FL GCM output (high resolution)
- Common file types and metadata
- Need to work together on a “unified set of climate scenarios” for Florida.



Questions?

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