Global Climate Change: Vulnerability Assessment & Modeling Scenarios for Water Resources Management in South Florida

Jayantha Obeysekera
Jenifer Barnes
Winnie Said
Luis Cadavid
Michelle Irizarry
Paul Trimble
Tibebe Dessalegne-Agaze

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Definition of Climate Change

- **"Any change in climate over time, whether due to natural variability or as a result of human activity."**

  (IPCC, AR4)

- **Climate change "*commitment*":**

"the further increase of temperature, or any other quantity in the climate system that changes in response to an external forcing that continues to change if the forcing stops increasing and is held at a constant value …"

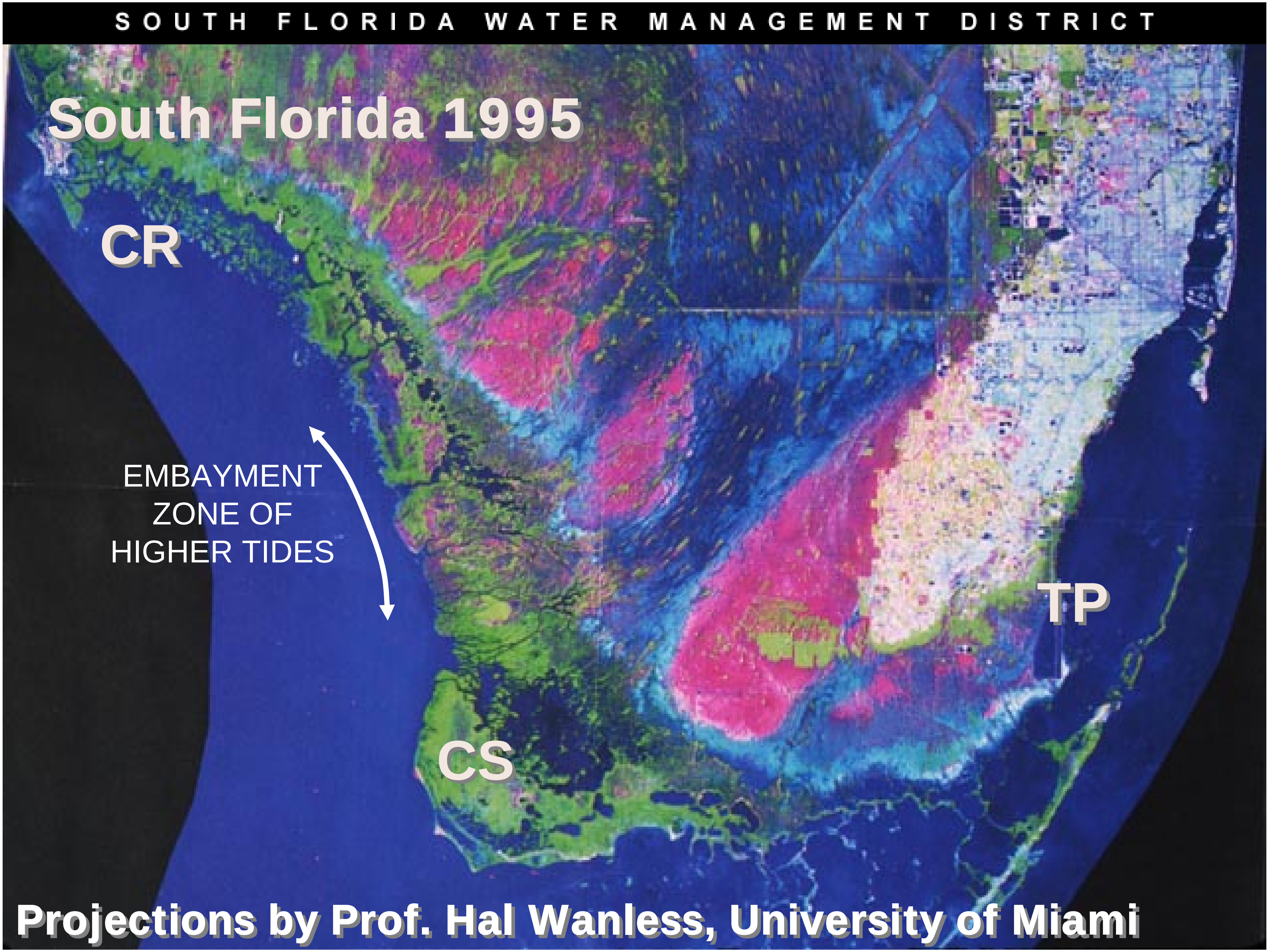
Global Trend – Human Inflluence

- **Important Climate Change Trends**
  - **Fewer cold days & nights.**
  - **More frequent hot days & nights.**
  - Warm spells/heat waves.
  - Heavy precipitation events.
  - **Increased drought effects.**
  - **Increased tropical cyclone activity.**
  - **Increased extreme high sea level.**
- **Impact on Florida???**

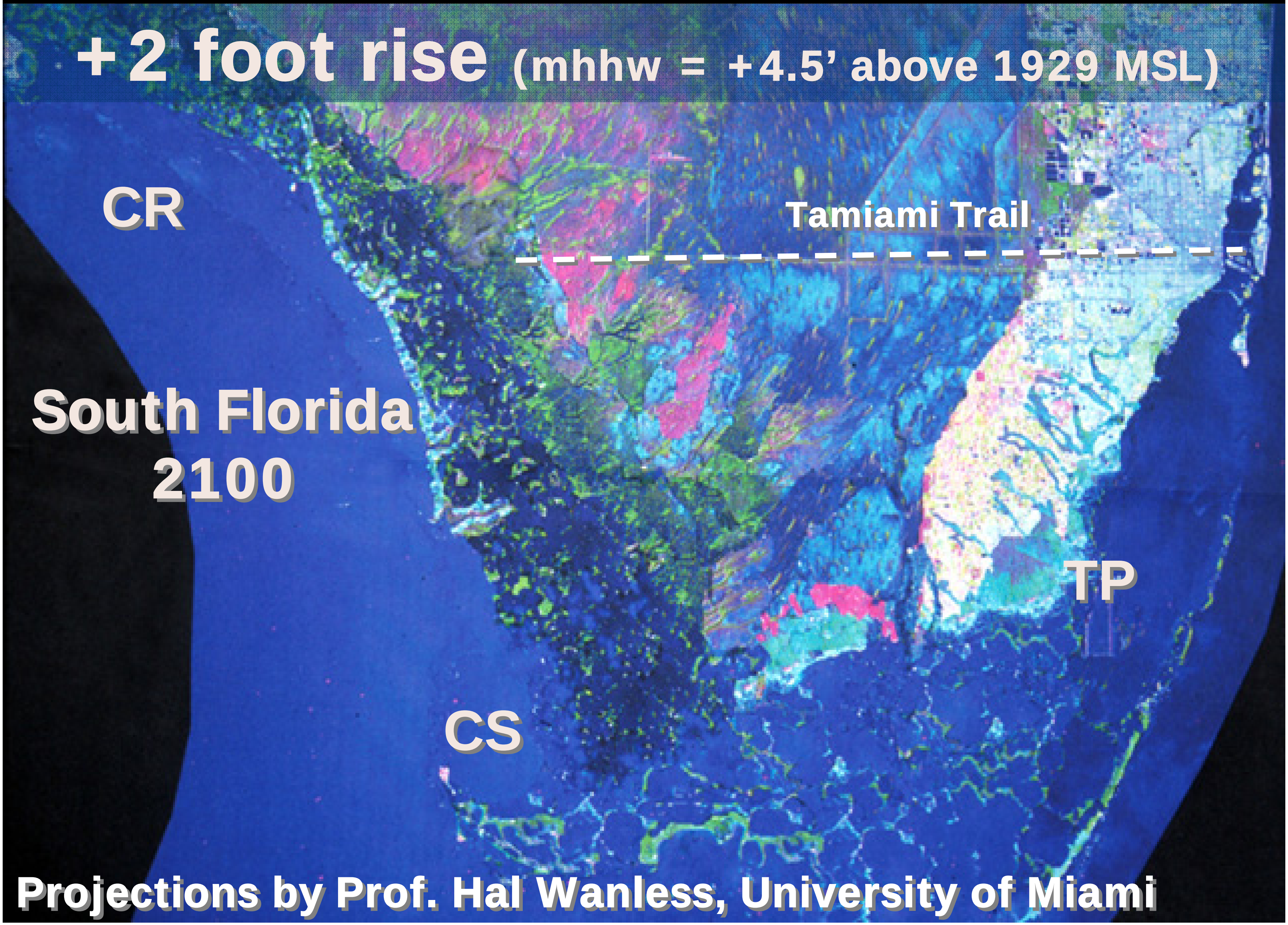
- According to IPCC, humans were most likely the cause of these trends.
- In addition, these trends are virtually certain, very likely, and **likely** to continue.

Climate Change : Concerns in Water Resources Management in S. Florida

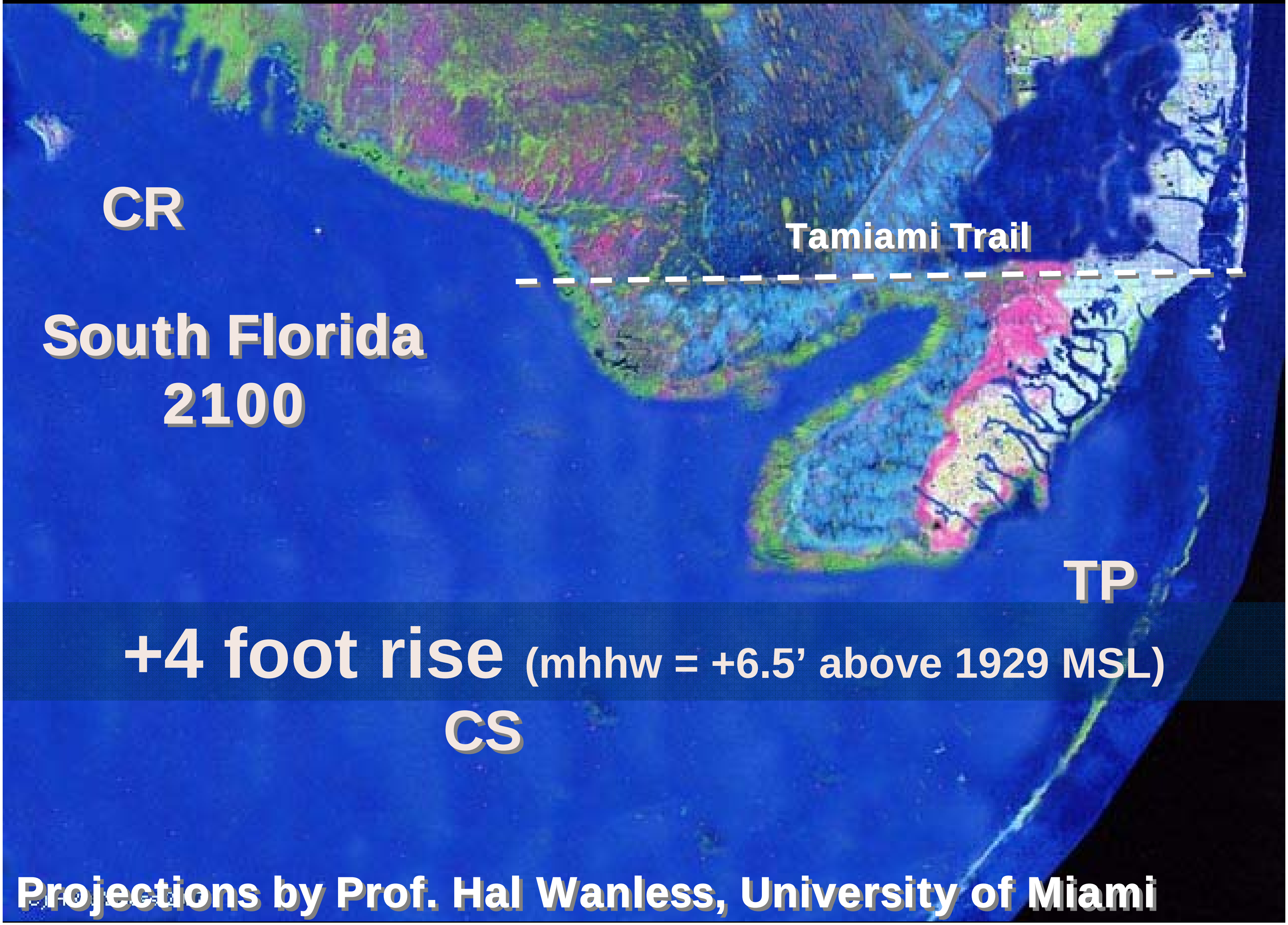
- **Landscape impacts**, direct effects on existing infrastructure and ecosystems (Coastal Watersheds, Coastal Ecosystems, Everglades)
- **Infrastructure Planning**
  - Water shortages due to changes in atmospheric inputs and outputs (Rainfall & Evapotranspiration)
  - Impact of Sea Level Rise on coastal wellfields and structures
- **Water Resources Operations**
  - Operational Planning (Seasonal and Multi-seasonal)
  - Flood Control Operations


SOUTH FLORIDA WATER MANAGEMENT DISTRICT
South Florida 1995
CR
EMBAYMENT
ZONE OF
HIGHER TIDES
TP
CS
Projections by Prof. Hal Wanless, University of Miami

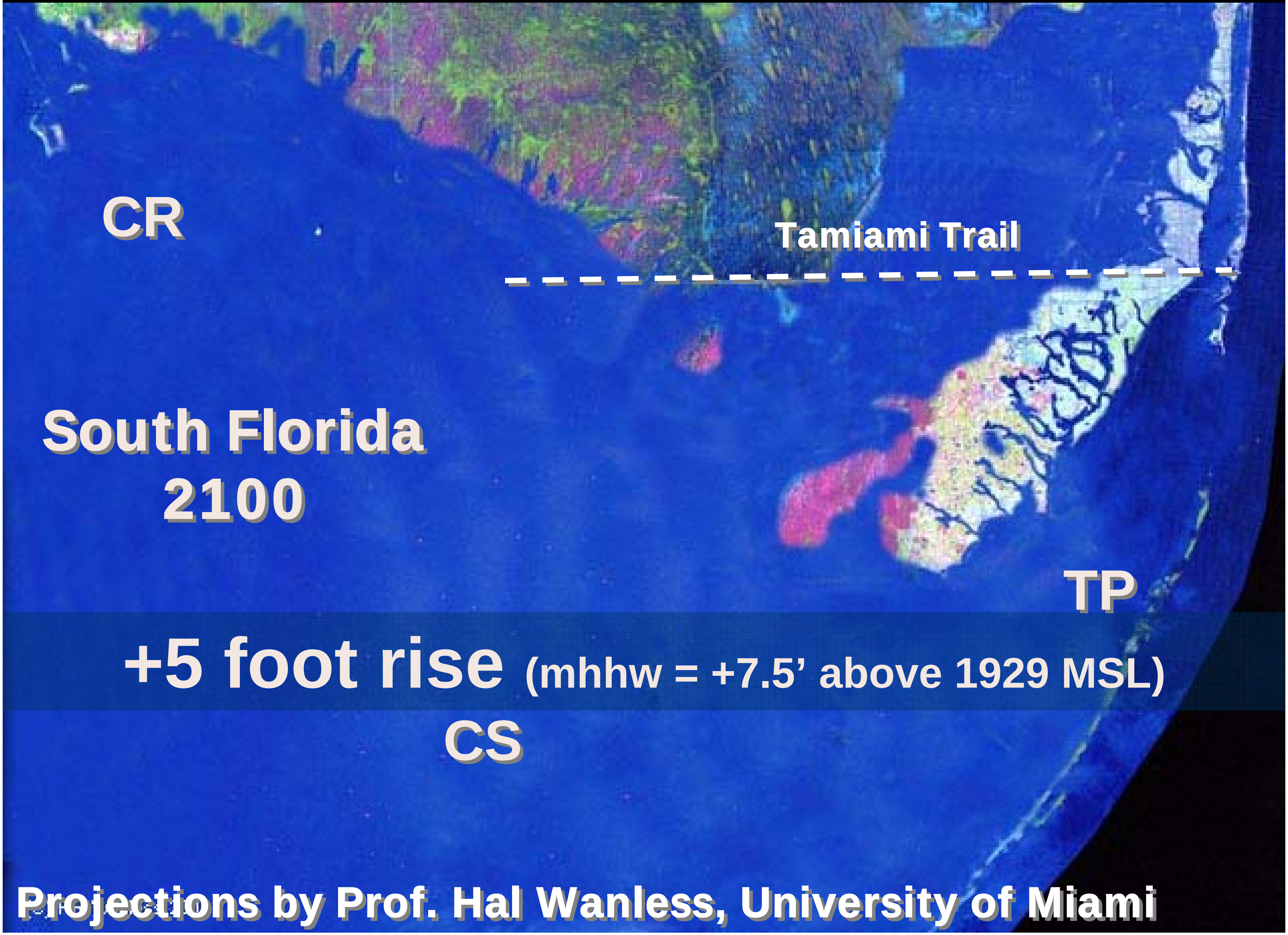
SOUTH FLORIDA WATER MANAGEMENT DISTRICT



SOUTH FLORIDA WATER MANAGEMENT DISTRICT



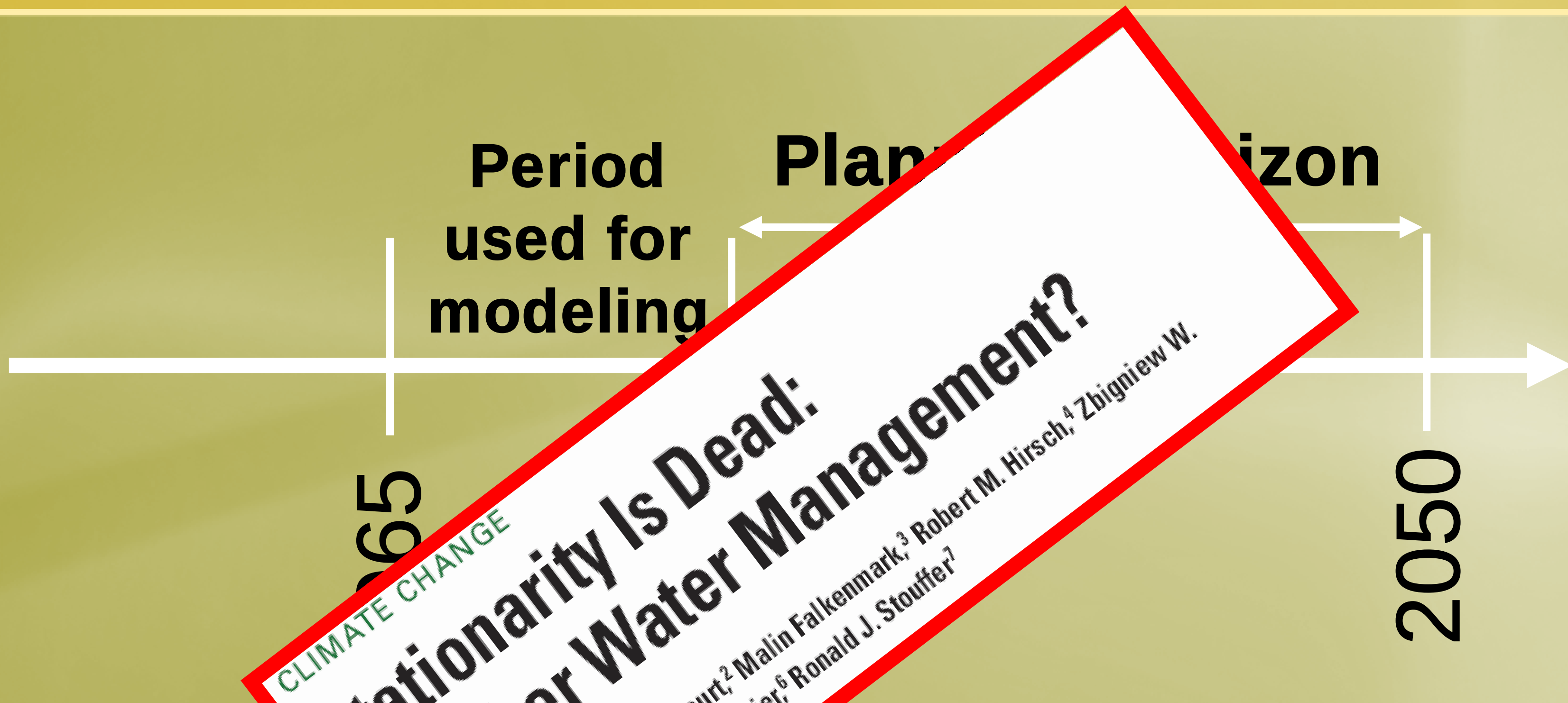
S O U T H   F L O R I D A   W A T E R   M A N A G E M E N T   D I S T R I C T



Nature of the Climate Change Problem

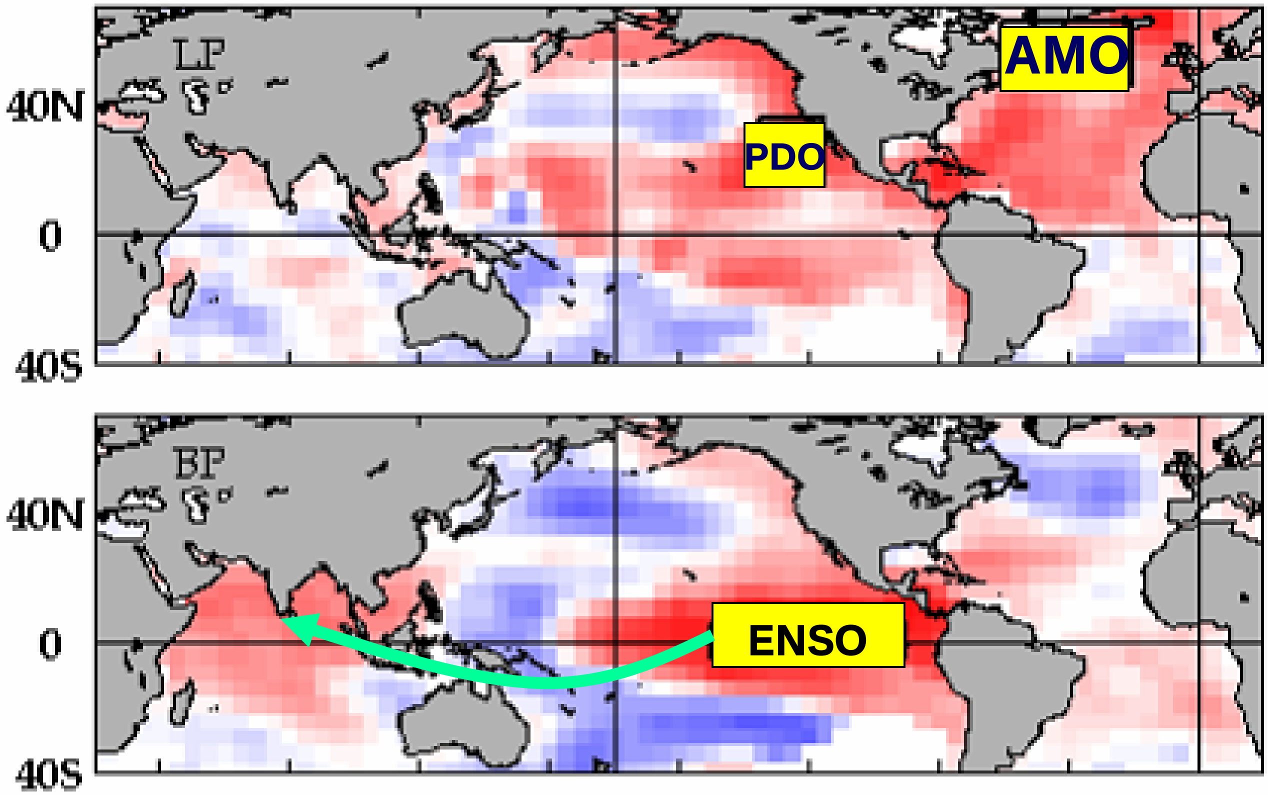
(Rik Lewis, MWH)

Restoration Plan Evaluation



Assumpt… period used for modeling i… entative of the climate expected du… the future planning horizon (“<u>stationarity</u>”)

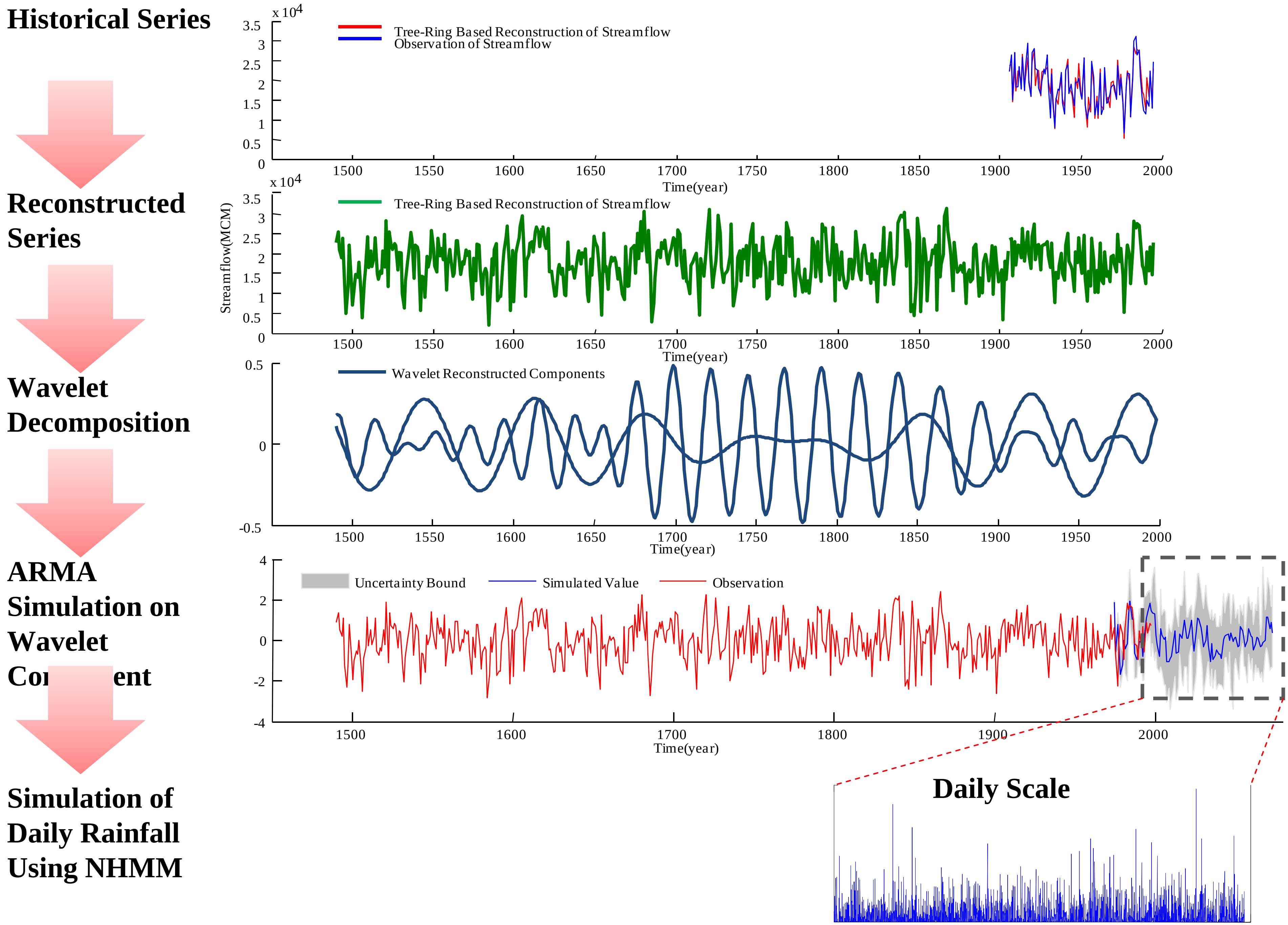
Natural Variability due to Teleconnections



AMO Atlantic Multi-decadal Oscillation
ENSO El Nino-Southern Oscillation
PDO Pacific Decadal Oscillation

Summary of What We Know

	Rainfall		Atlantic Hurricanes
	Wet Season	Dry Season	
El Niño	No clear pattern	Wetter	Less activity
La Niña	No clear pattern	Drier	More activity
AMO Warm Phase	**Wetter decades; drought still occur**		**Greater # of major storms**
AMO Cold Phase	**Drier decades; very wet years still occur**		**Lesser # of major storms**



Historical Series
Reconstructed Series
Wavelet Decomposition
ARMA Simulation on Wavelet
Simulation of Daily Rainfall Using NHMM
x 10^4
Tree-Ring Based Reconstruction of Streamflow
Observation of Streamflow
Time(year)
Streamflow(MCM)
Wavelet Reconstructed Components
Uncertainty Bound
Simulated Value
Observation
Daily Scale

Climate change Due to Human Activity

Greenhouse Gasses

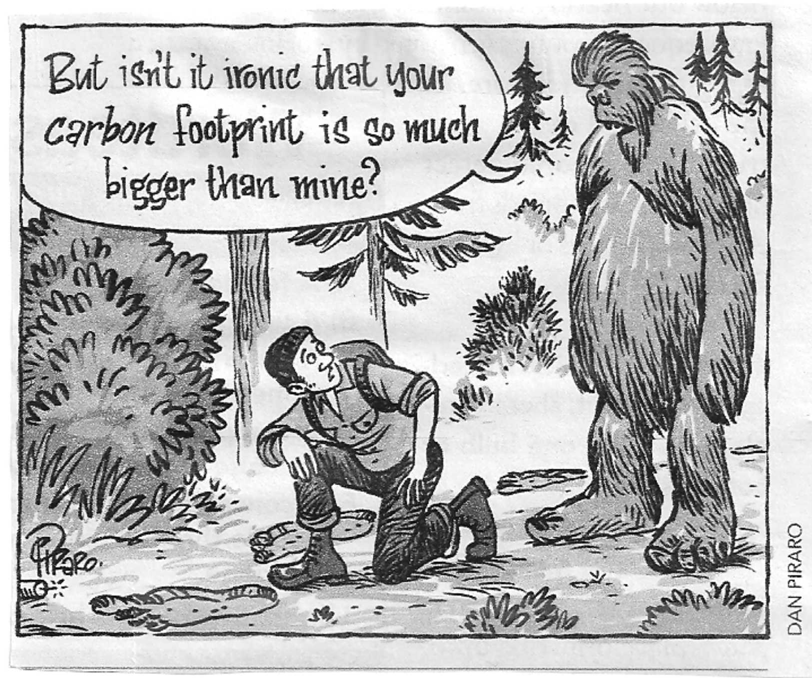
Global Warming

Climate

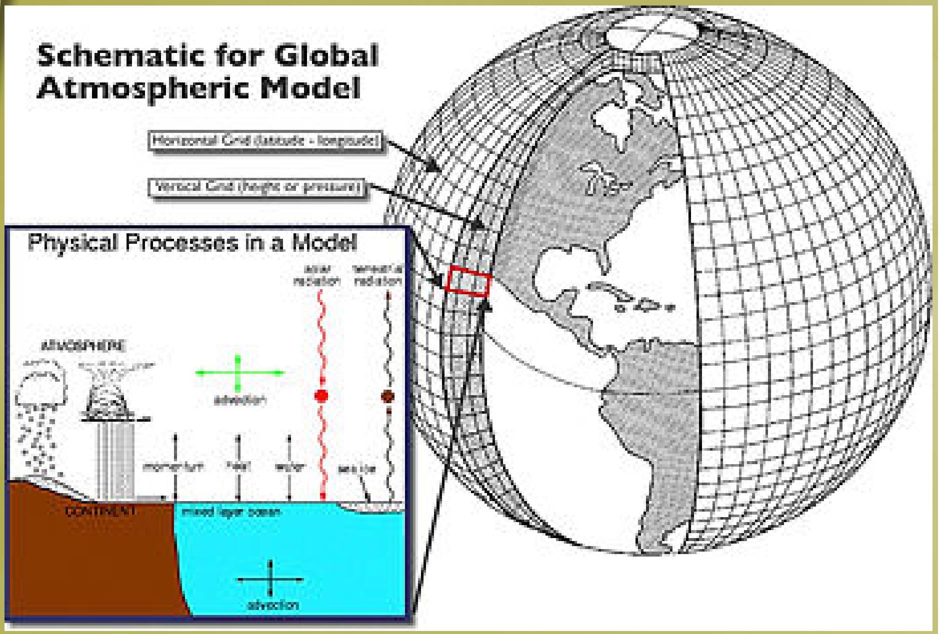
Less certain

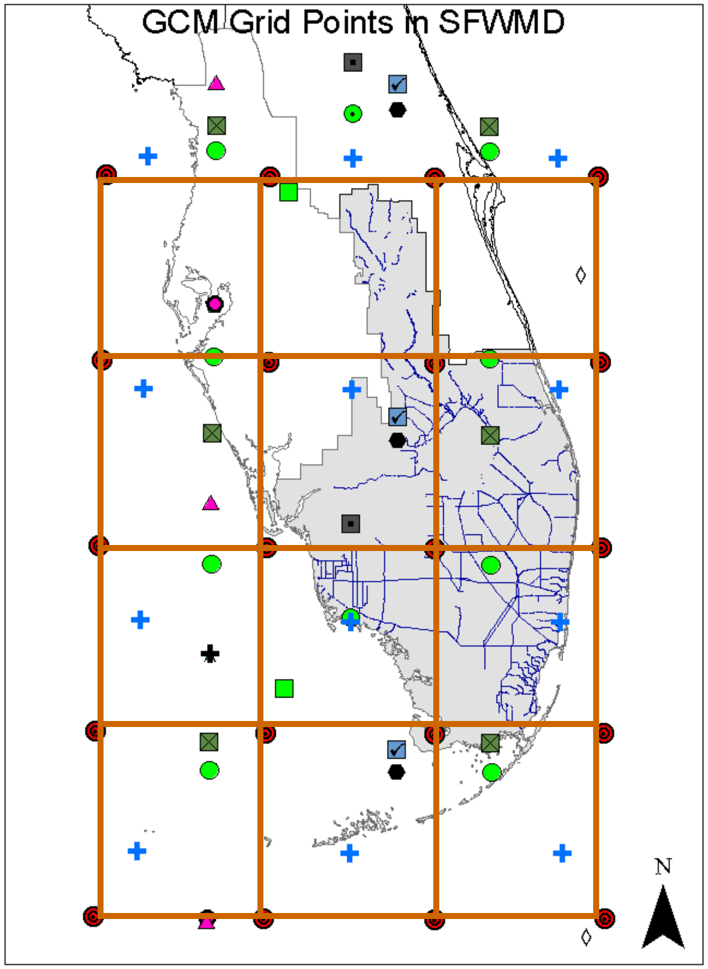
Sea Level Rise

Already happening

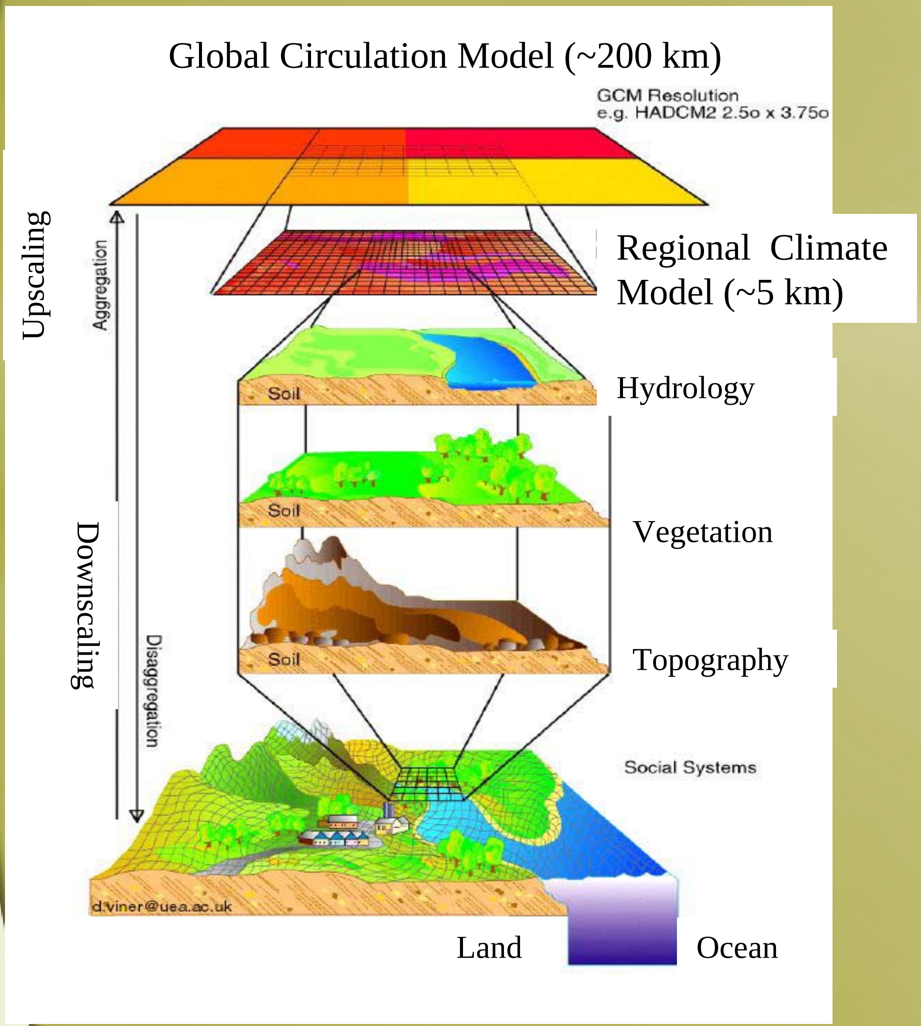


Atmosphere-Ocean General Circulation Models





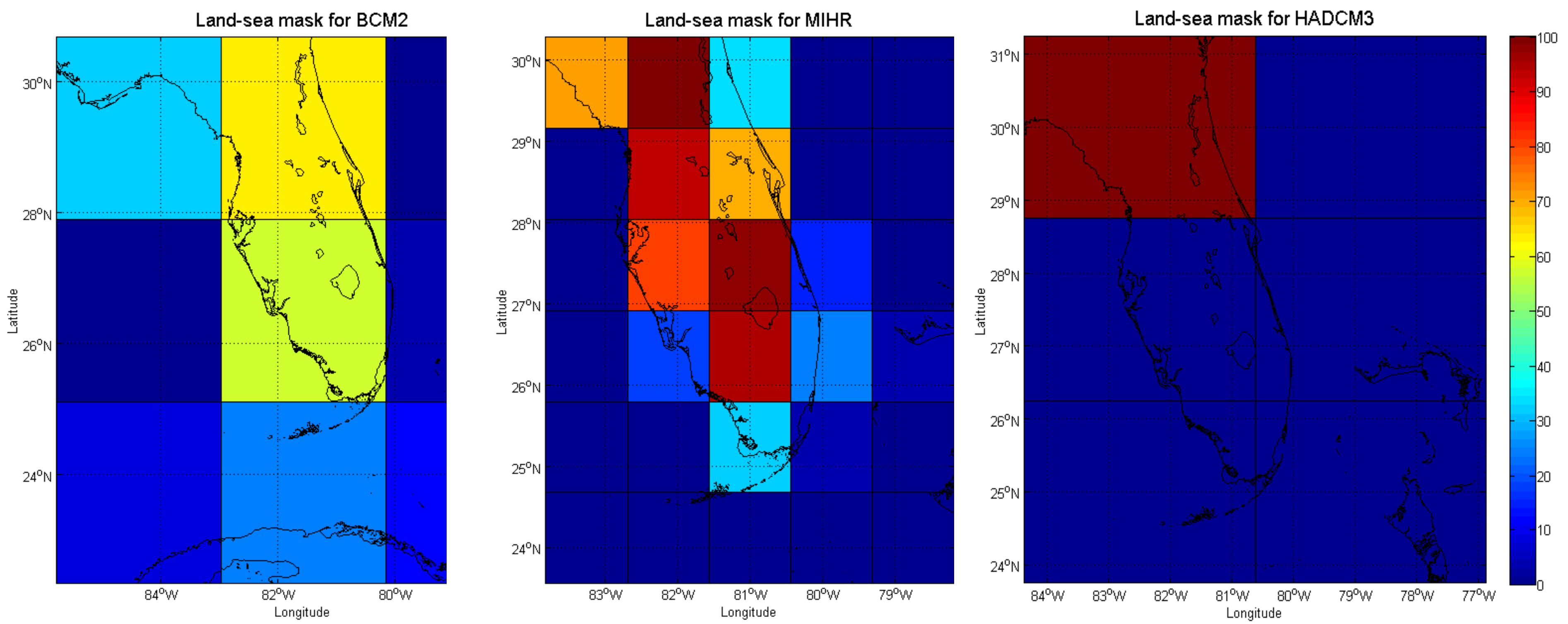
Climate Modeling in South Florida



General Energy and Mass Transfer - Regional Scale Atmospheric Model

(GEMRAMS)

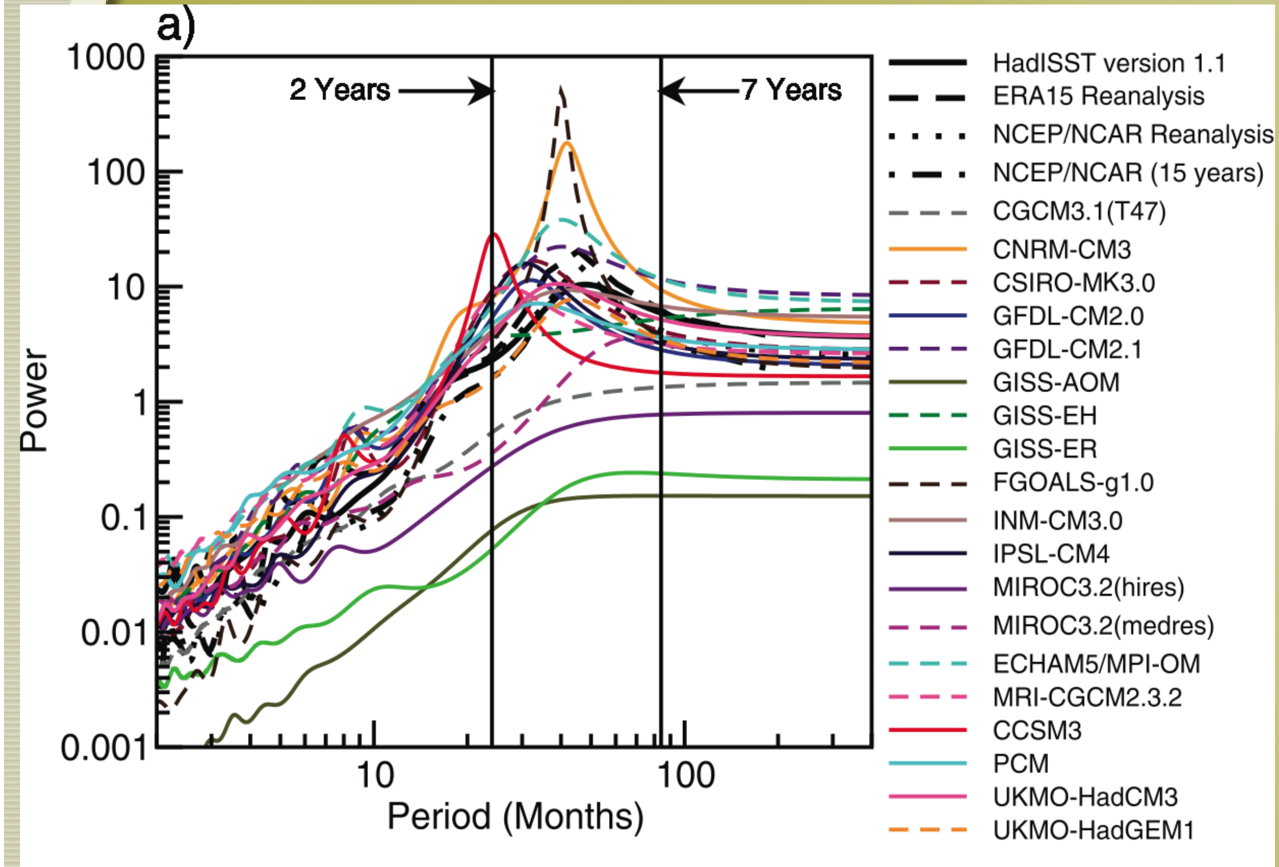
How well is Florida represented in GCMs?



Uncertainties in GCM predictions due to:

- **Poor resolution – South Florida not even modeled in some GCMs; greater errors at smaller scales**
- **From IPCC AR4-WG1, Ch. 8 - Simulation of tropical precipitation, ENSO, clouds and their response to climate change, etc.**

Present-day Simulation of ENSO

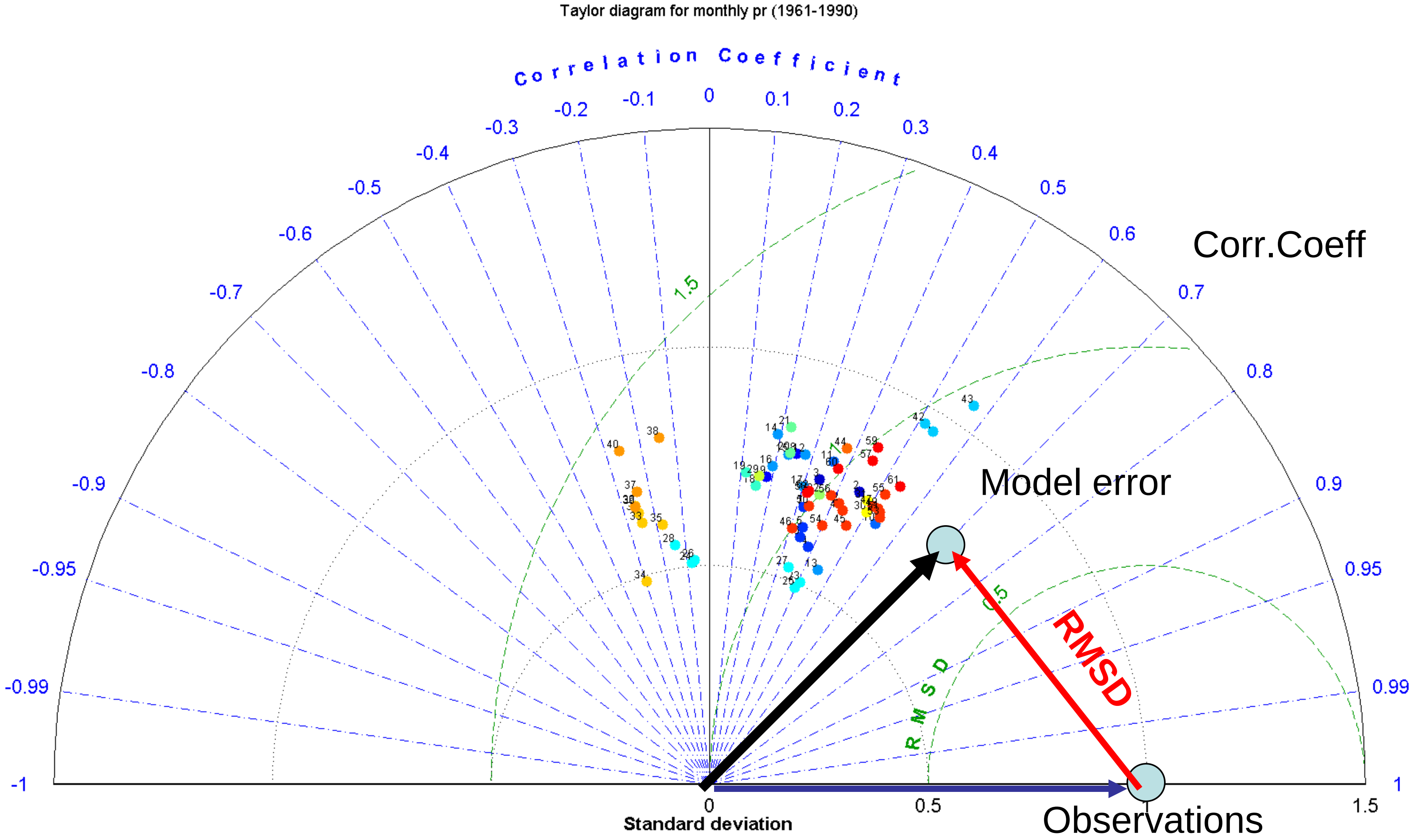


IPCC AR4-WG1, Figure 8.13 –

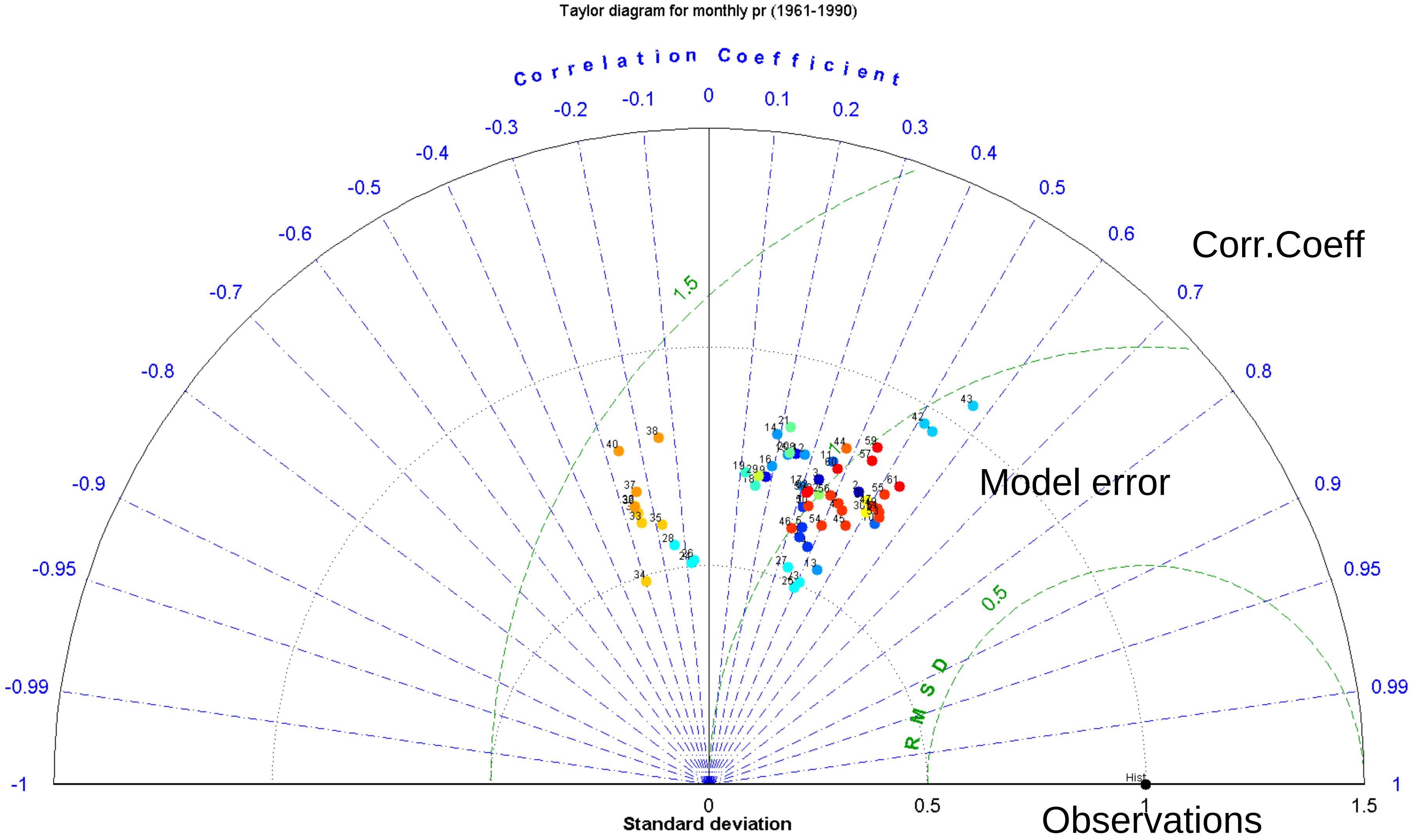
Maximum entropy power spectra of surface air temperature averaged over the NINO3 region.

- **Systematic errors in both the simulated mean ENSO state and natural variability**
- **Most AOGCMs produce ENSO variability that occurs on time scales considerably faster than observed**

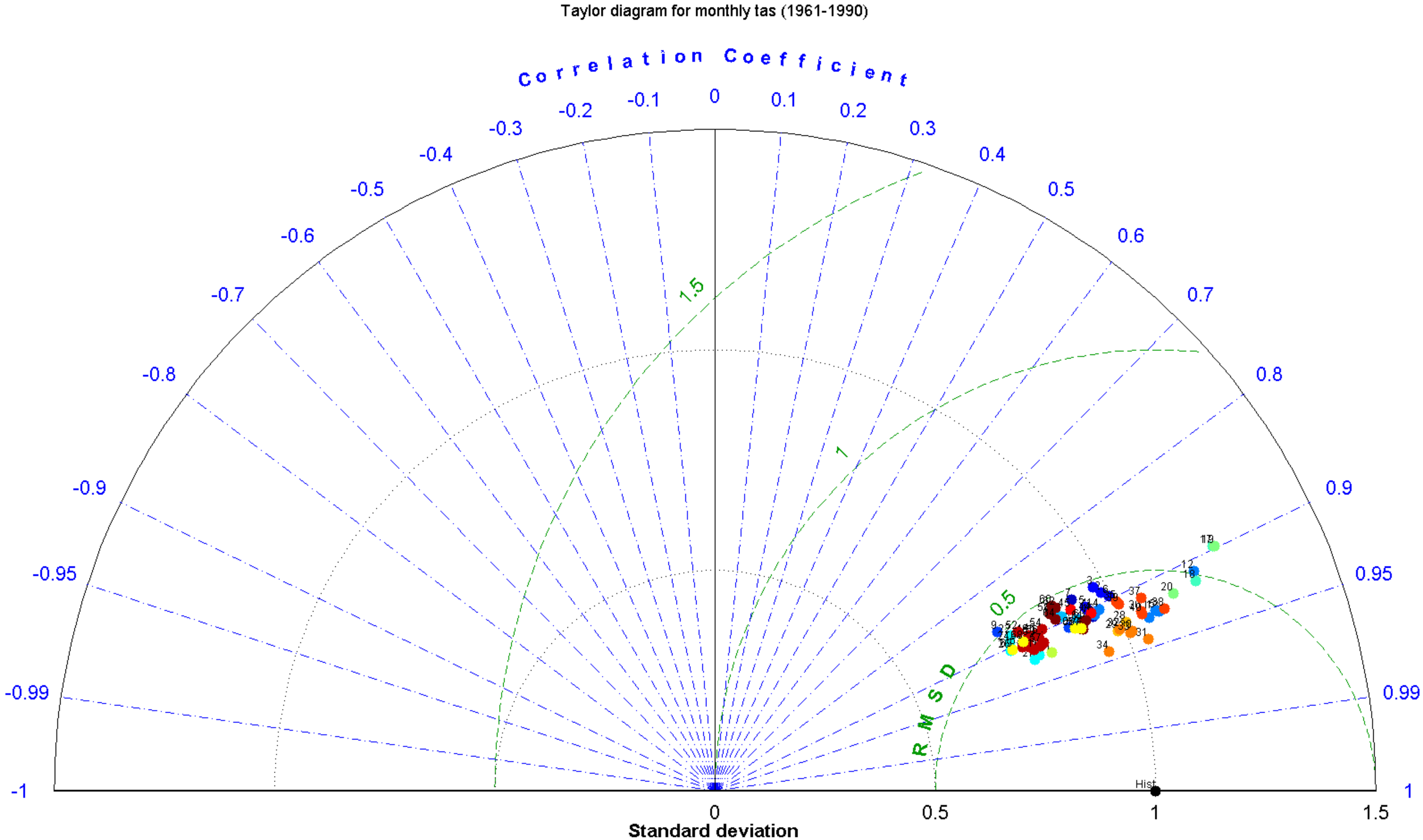
Taylor Diagram: Monthly Precipitation



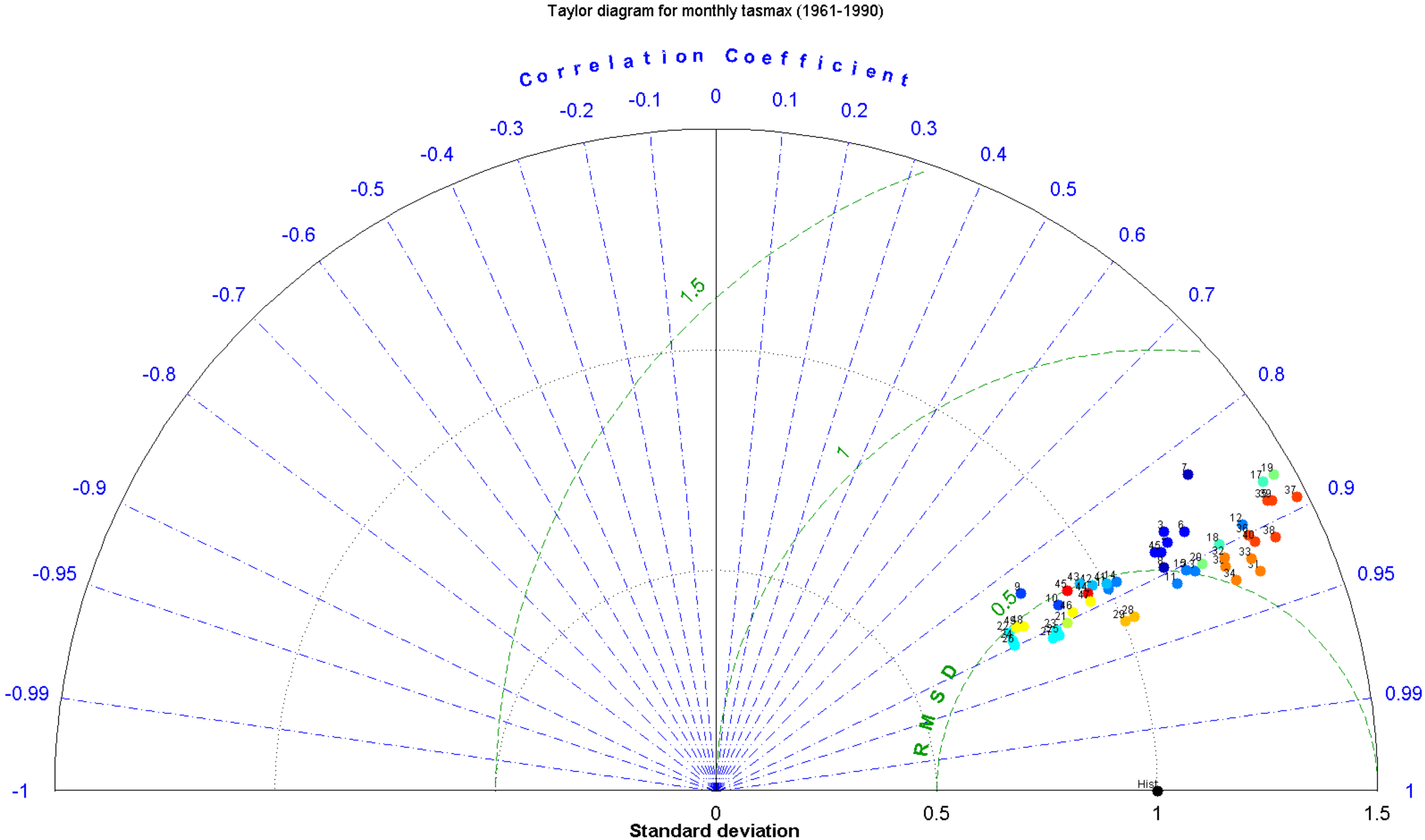
Taylor Diagram: Monthly Precipitation



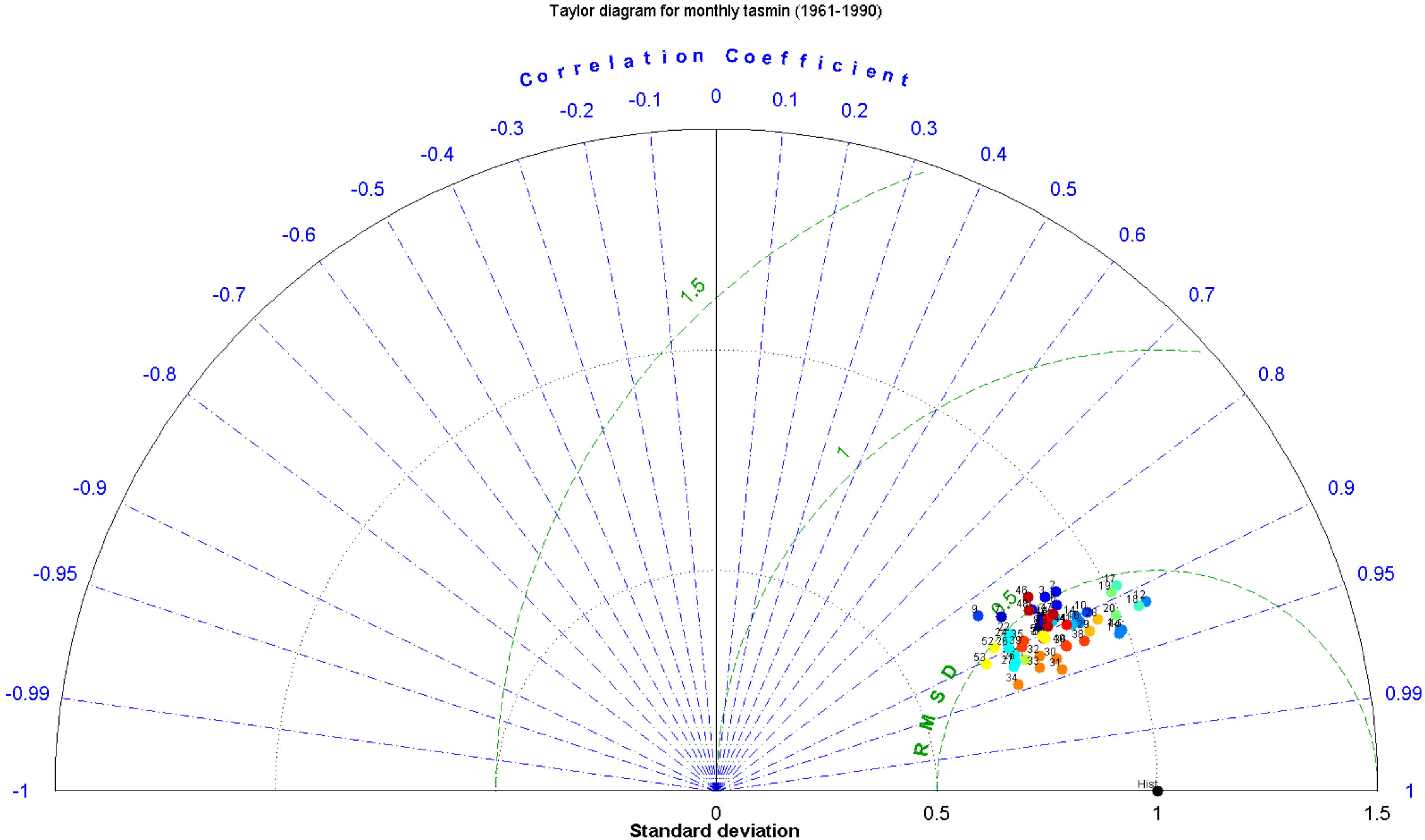
Daily Average Temperature



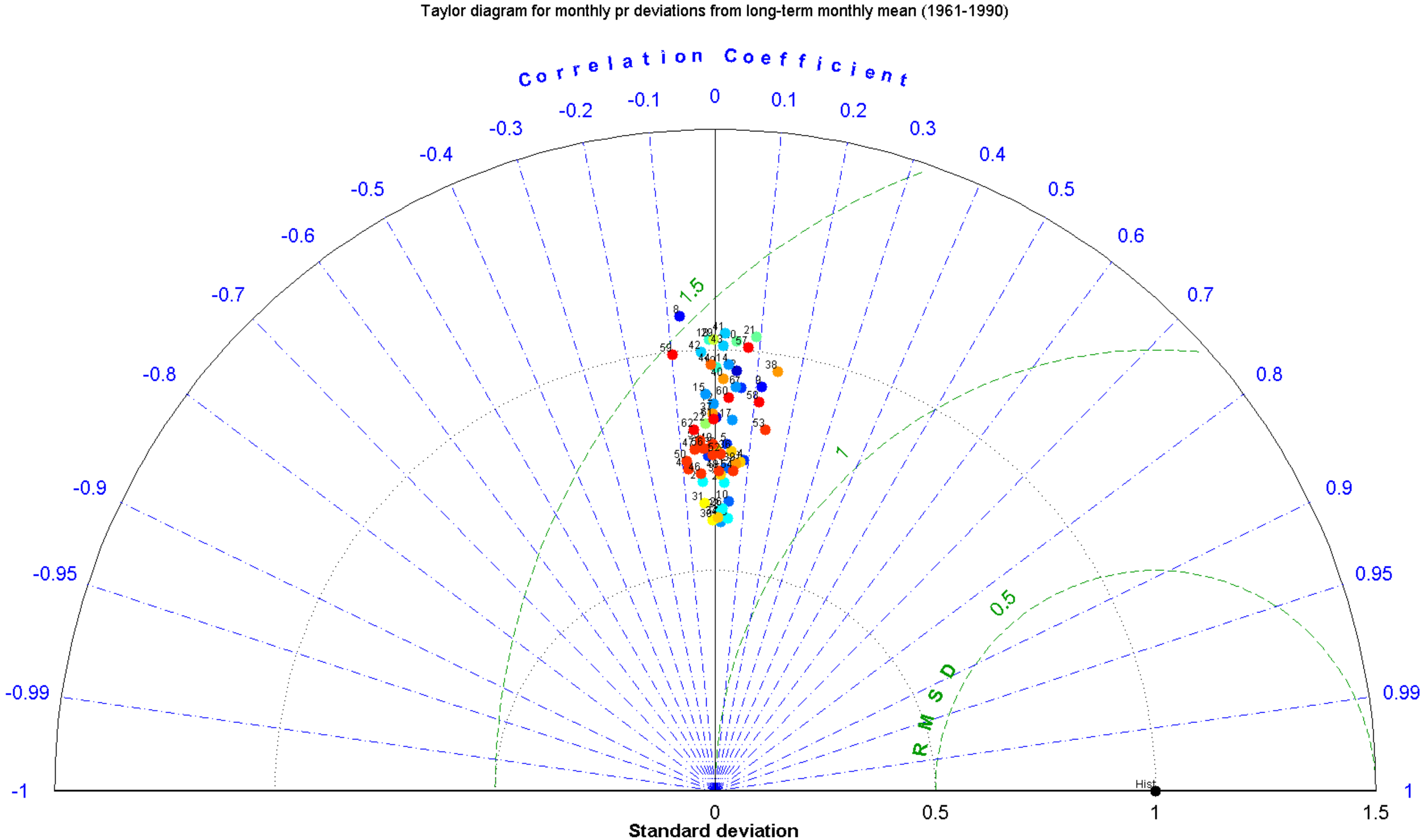
Daily Maximum Temperature



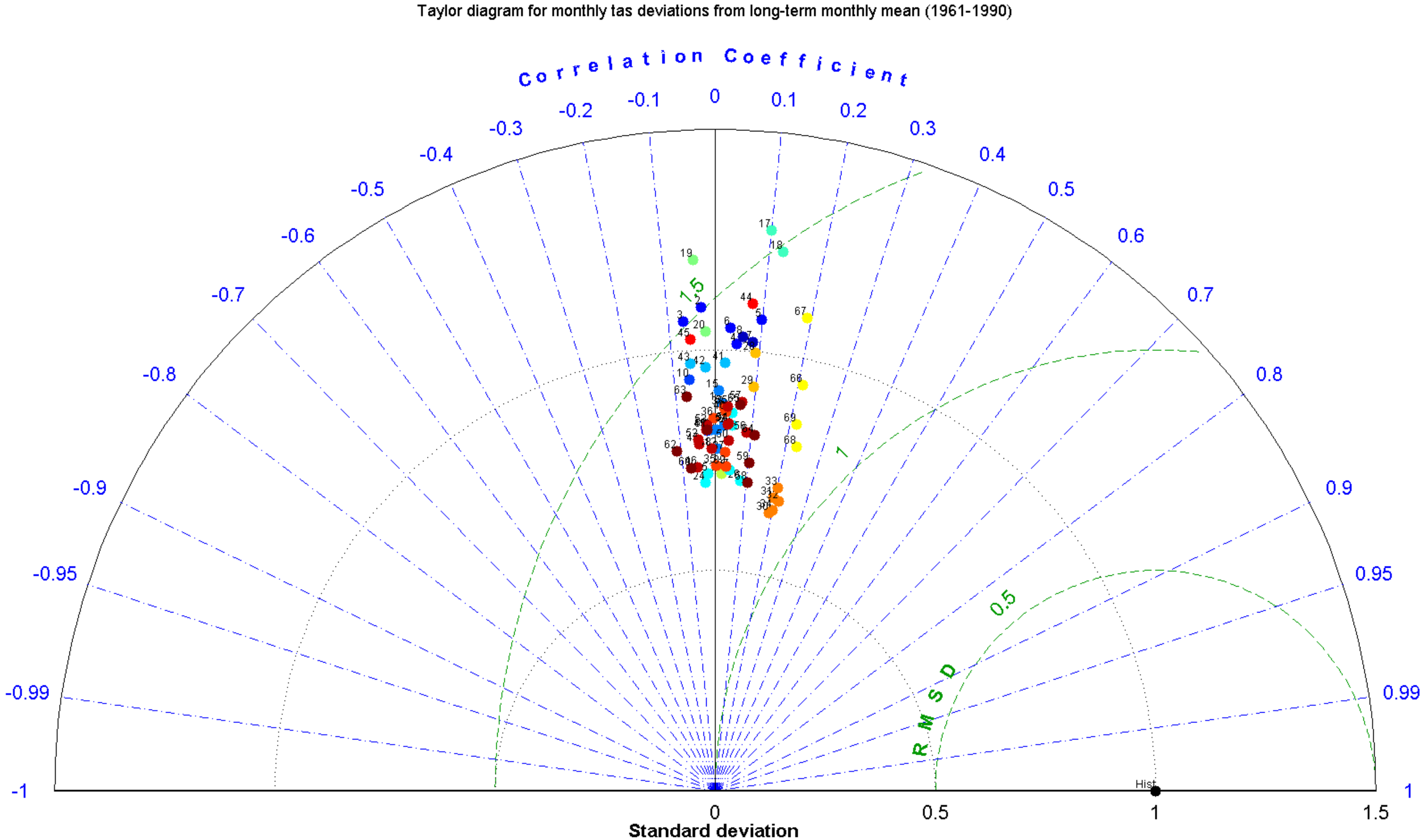
Daily Minimum Temperature



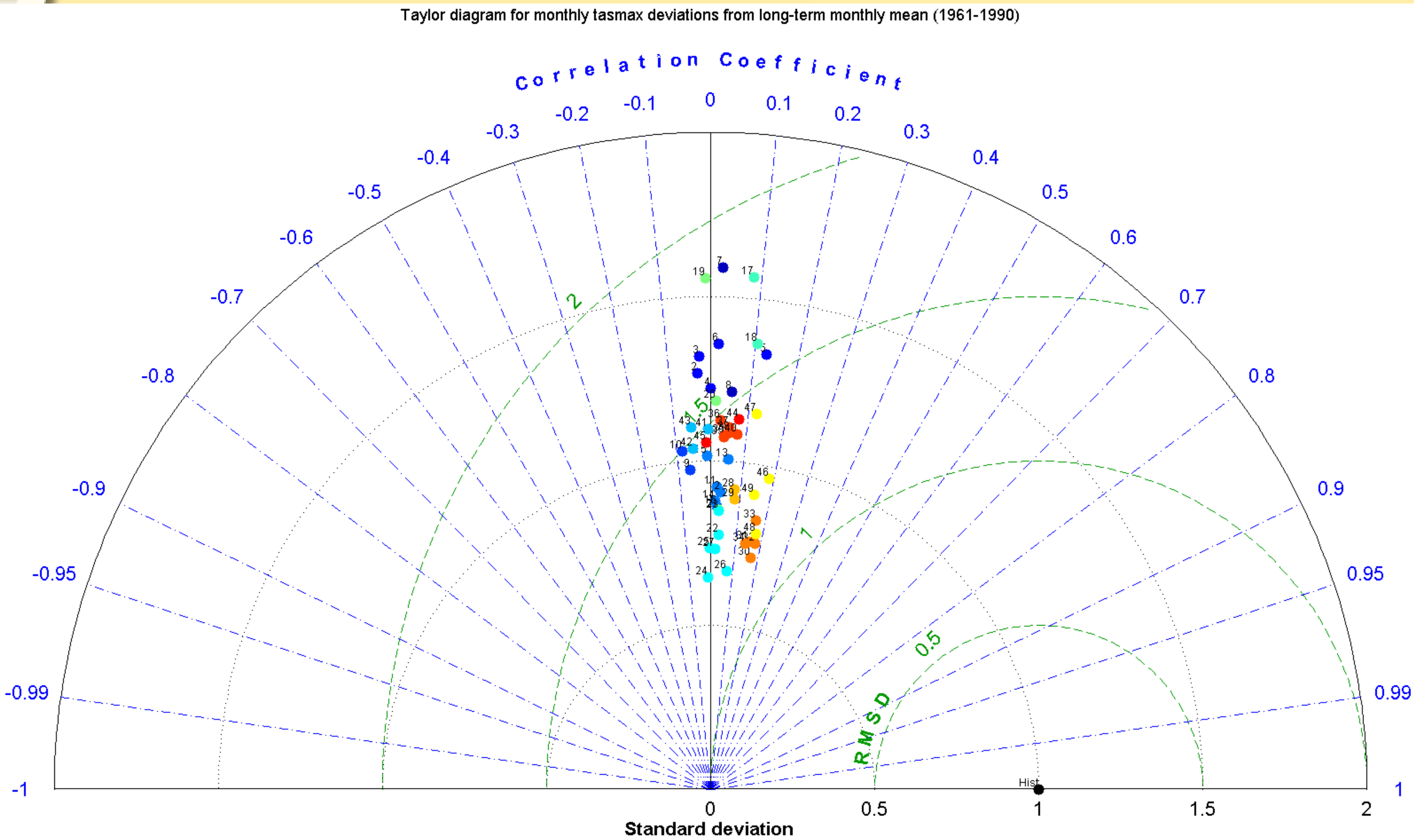
Precipitation: Deviations from the means



Daily Mean Temperature: Deviations from the means

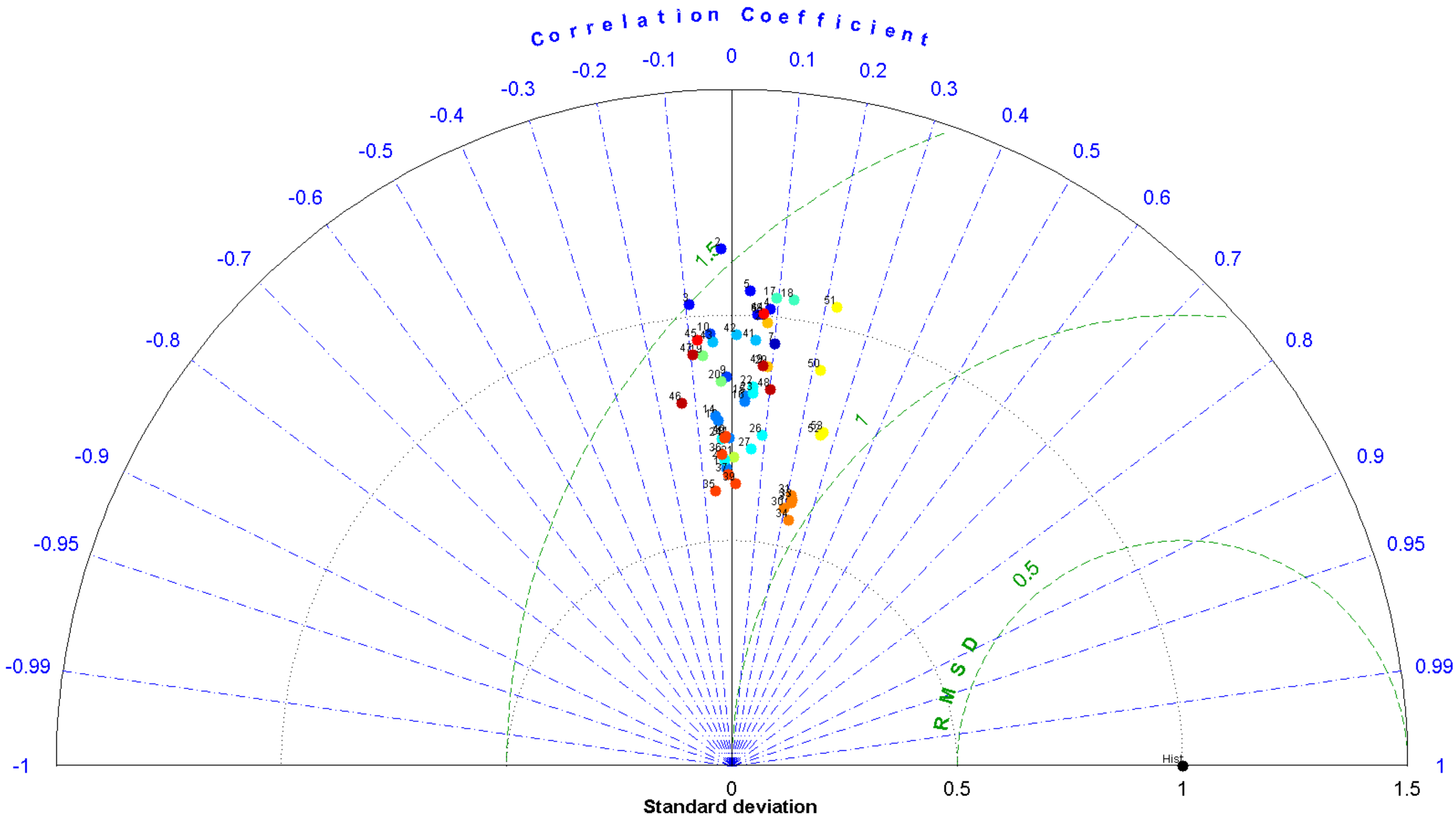


Daily Maximum Temperature: Deviations from the means



Daily Minimum Temperature: Deviations from the means

Taylor diagram for monthly tasmin deviations from long-term monthly mean (1961-1990)



System Sensitivity to Climate Change and Sea Level Rise

- SFWMM (2x2) Sensitivity Runs
  - BASE Case (2050 without Project)
  - CERP0 (2050 with CERP)
  - 2050 and CERP0 with Climate Change (CC)
  - Existing Condition (EC) with and without Sea Level Rise (SLR)
- Comparison shown for:
  - CERP0 minus BASE
  - EC+SLR scenario minus EC

Scientists on the Miami-Dade Climate Change Task Force:

- **“With what is happening in the Arctic and Greenland, [there will be] a likely sea level rise of** at least **1.5 feet in the coming 50 years and a total of** at least **3-5 feet by the end of the century, possibly significantly more. Spring high tides would be at +7 to +9 feet.**
- **“This does not take into account the possibility of a catastrophically rapid melt of land-bound ice from Greenland, and it makes no assumptions about Antarctica.”**
- **“The projected rises will just be the beginning because of further significant releases from Greenland and possibly Antarctica.”**

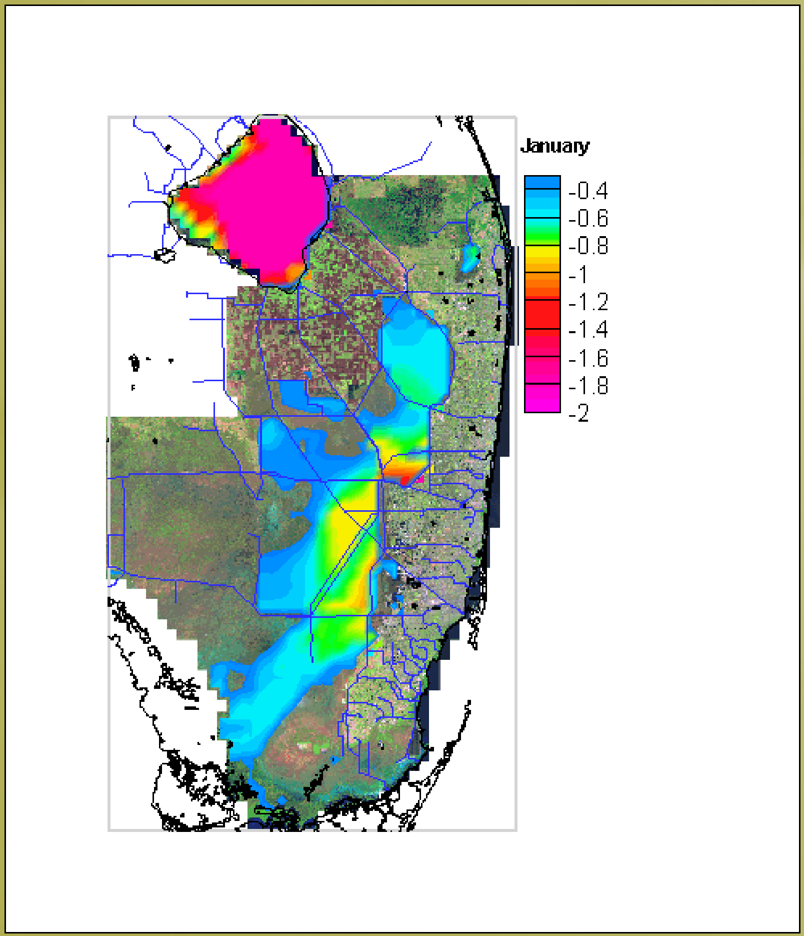
(September 20, 2007)

Climate Change Scenarios

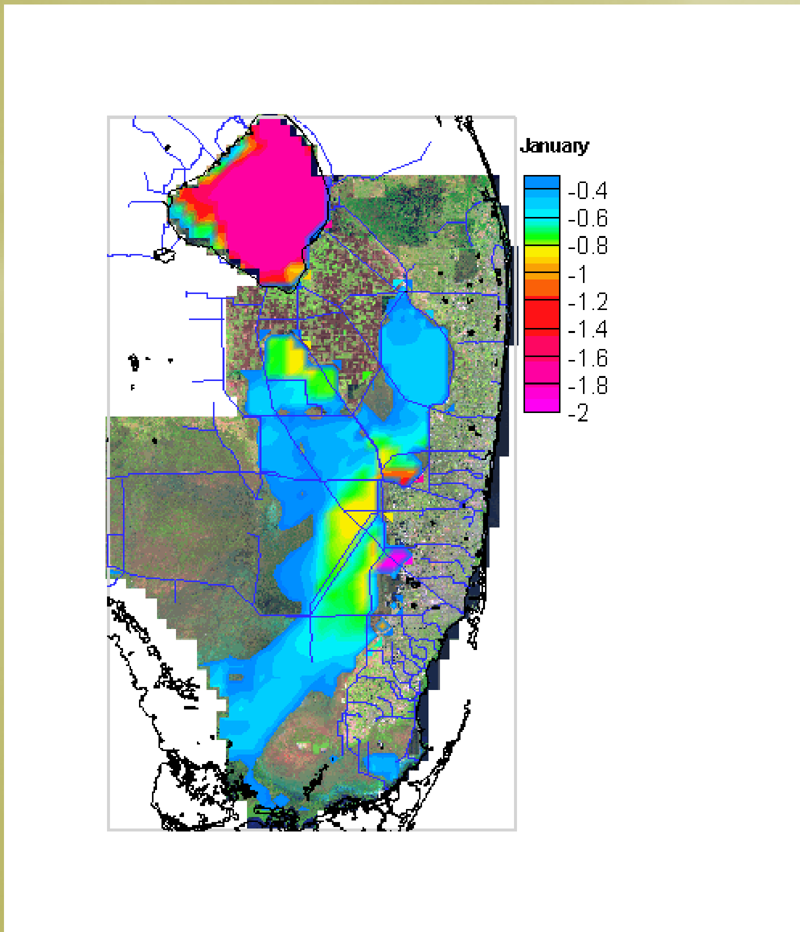
- Precipitation – ET scenario
  - 10% Decrease in Precipitation
  - ~6.5% decrease in Reference ET (as simulated by a 1.5° increase in Maximum Daily Temperature for simulating incoming solar radiation using the "Simple Method"
- Sea-Level Rise Scenario
  - 1.5 feet increase in Tidal Boundary Condition

Monthly Ponding Decrease

2050+CC minus 2050



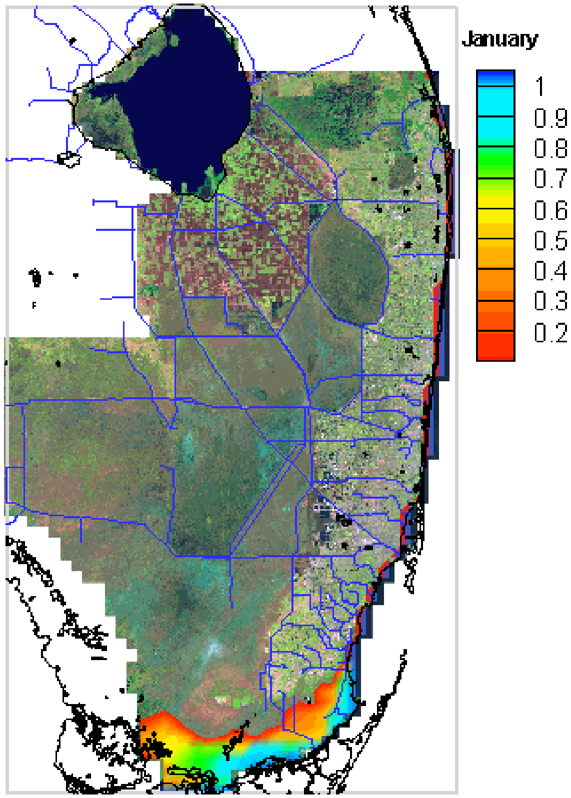
CERP0+CC minus CERP0



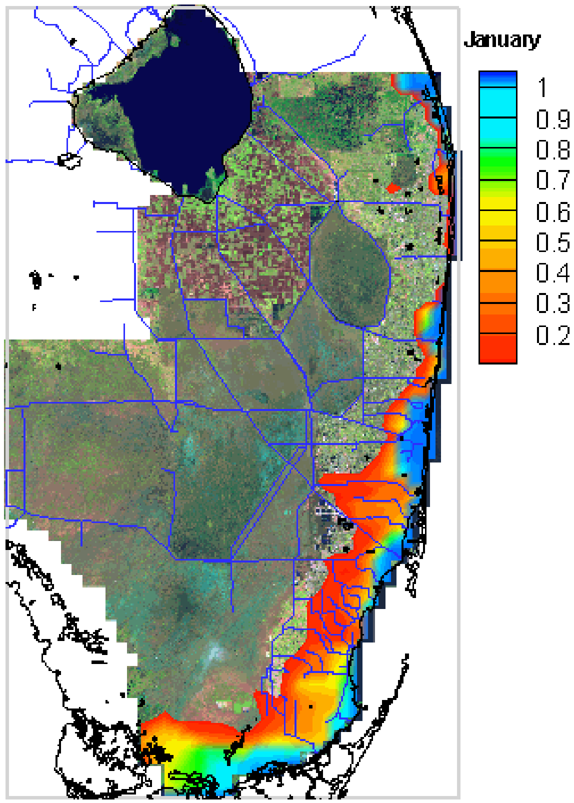
*Ponding decrase > 0.3 feet

Monthly Increase in Ponding & Water Surface due to SLR

EC+CC minus EC:Ponding >0.1 ft



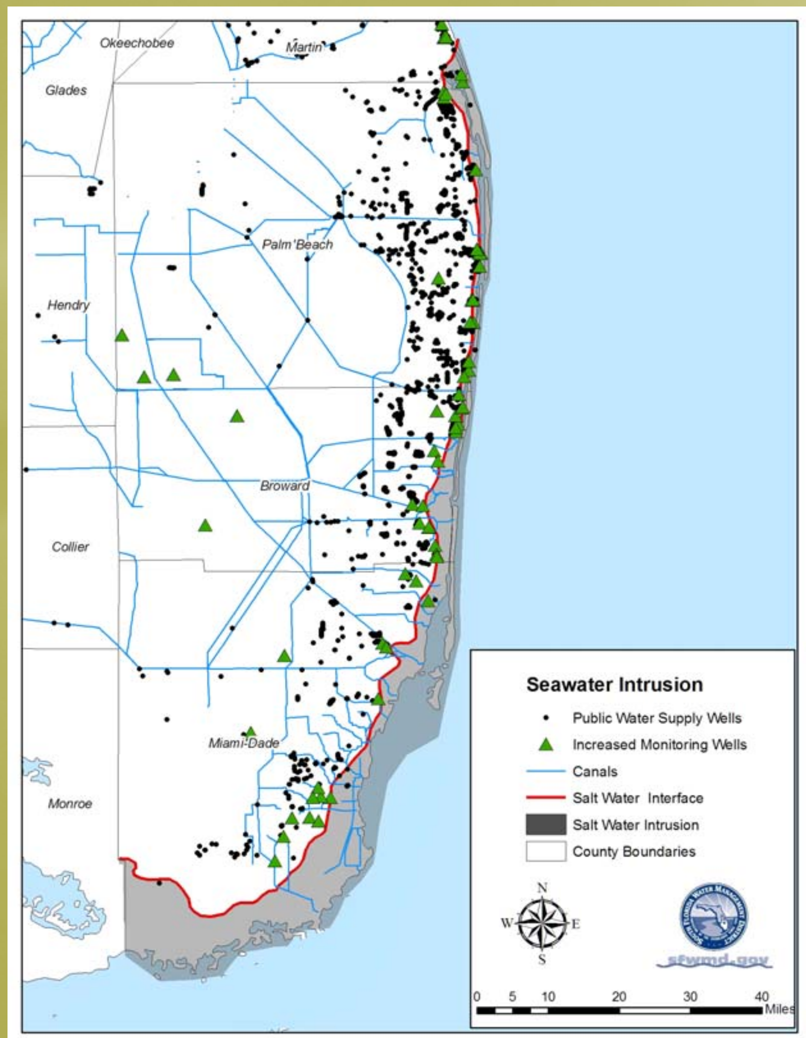
EC+CC minus EC:WSL > 0.1 ft

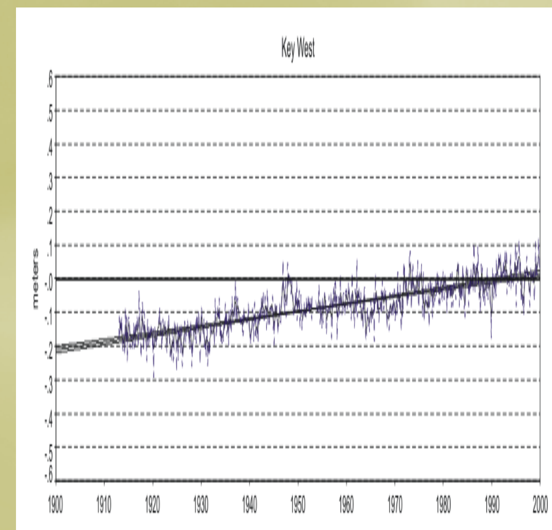


Potential Impacts of Sea Level Rise

- Increased saltwater intrusion in coastal areas
  - Impacts on coastal well fields
  - Contamination of other water supply sources
- Increased water levels in coastal canals to control salt water intrusion
  - Potential flooding impacts
- Increased damage from high tides and reduced flood control capacity
  - Potential flooding impacts

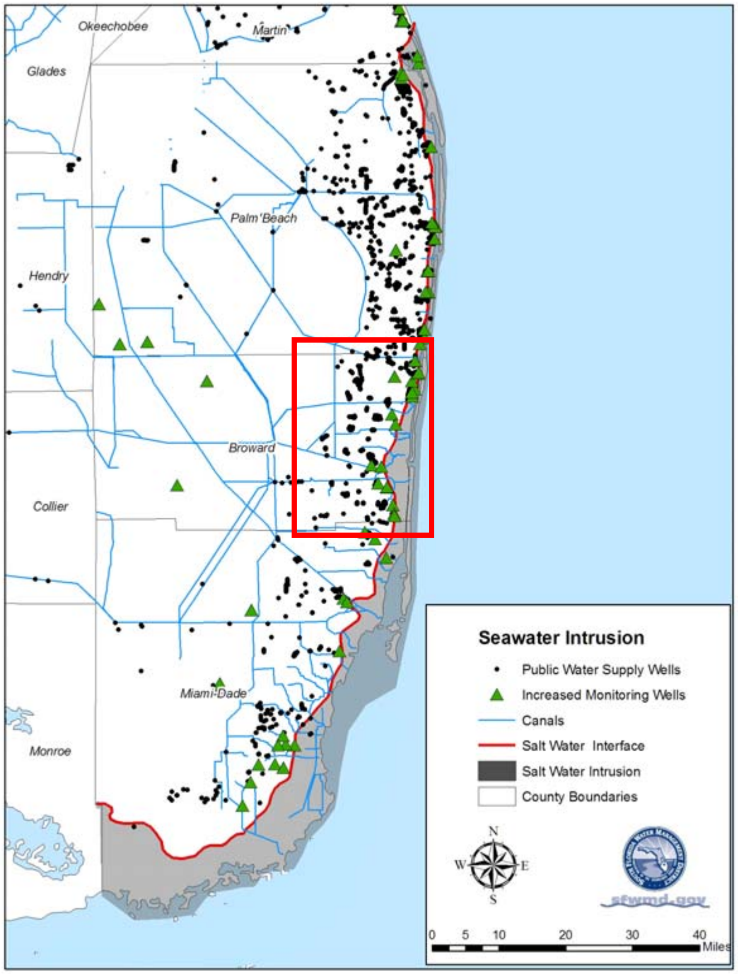
Saltwater Intrusion is already a threat to our coastal wellfields





SLR Trend - Key West

Impact on Coastal Wellfields

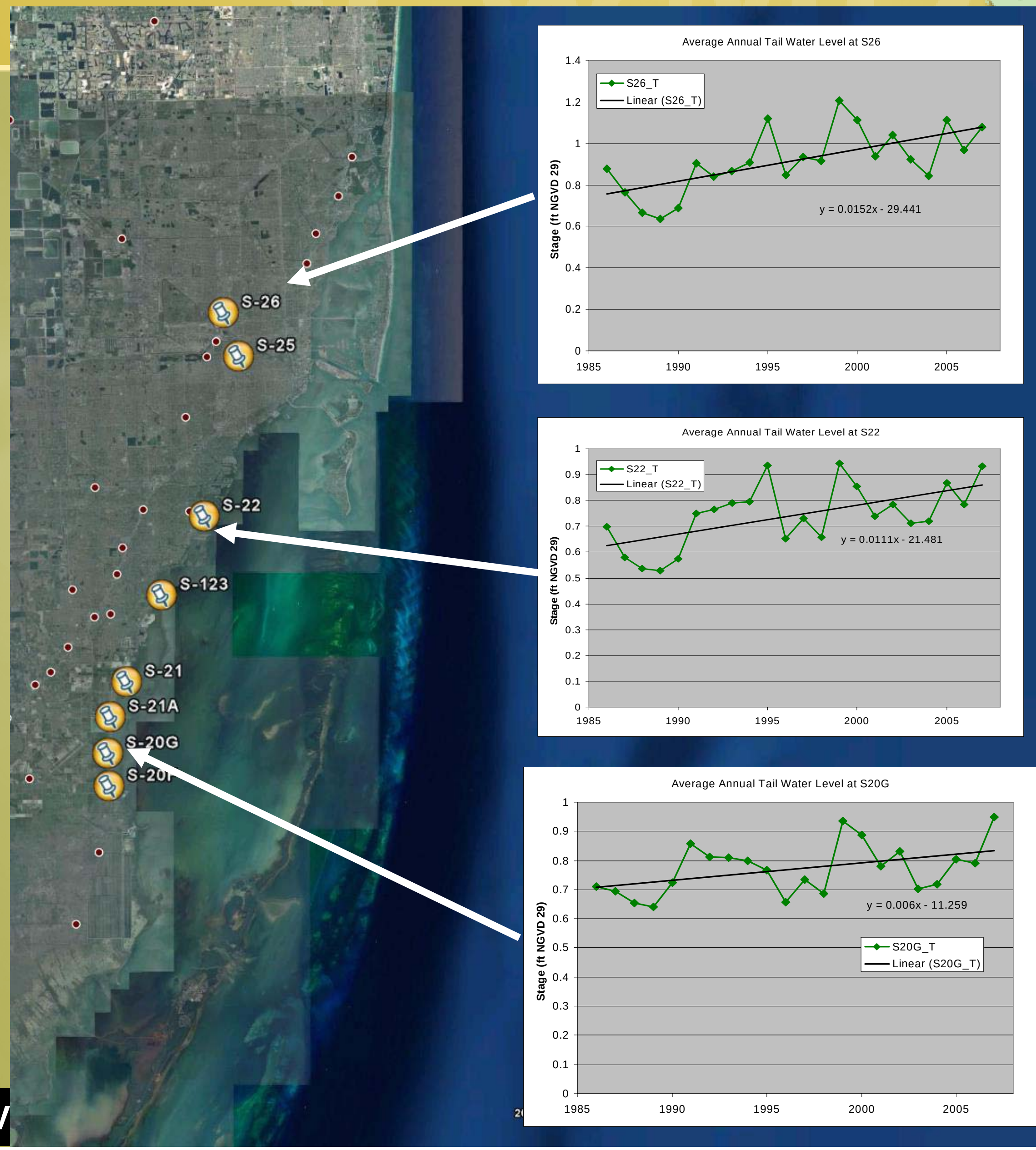


Present position of the saltwater interface

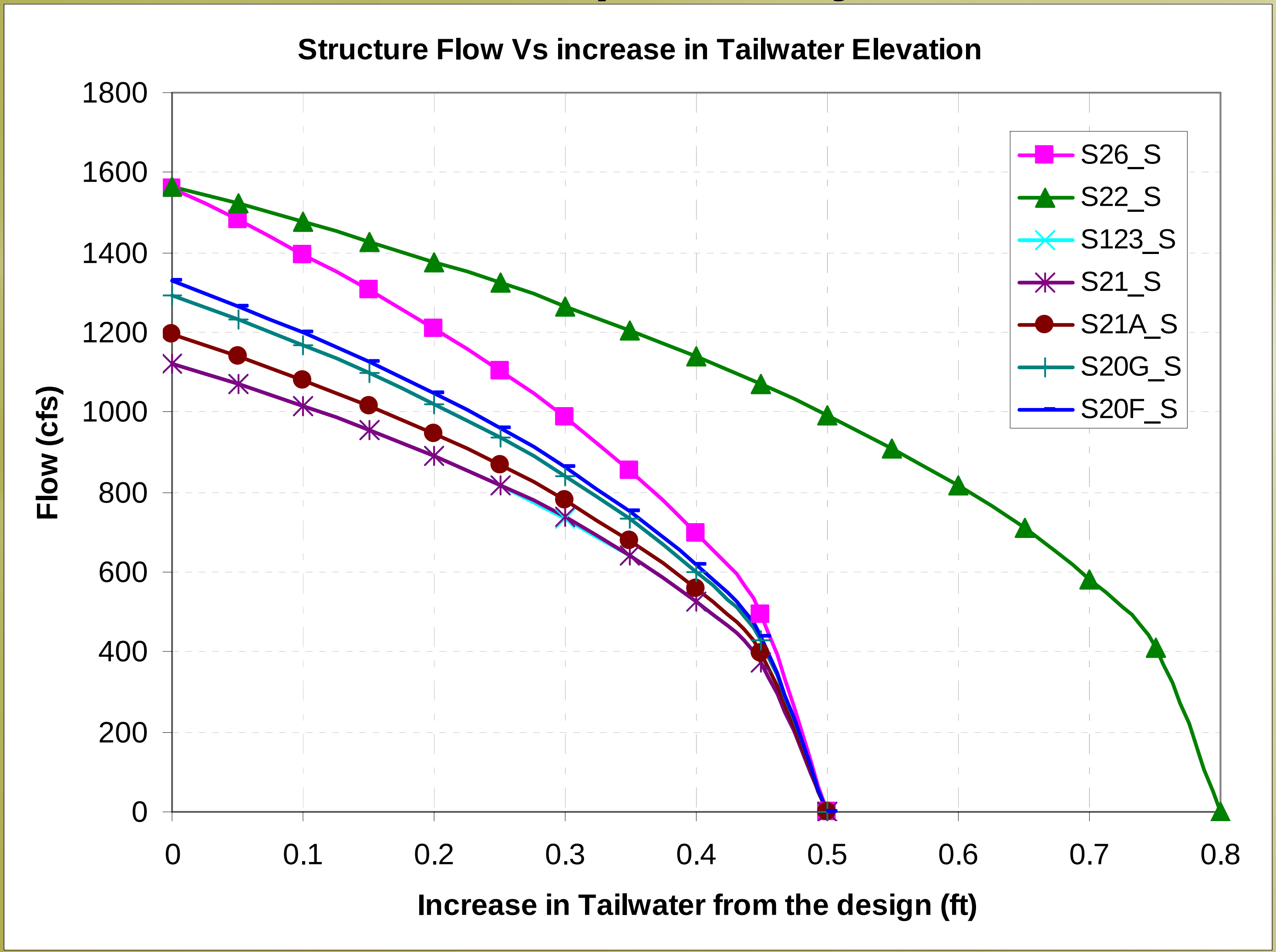
- Dausman & Langevin (USGS, 2004) simulated the migration of the saltwater interface in Broward County after 48 cm (1.6 ft) SLR over 100 years using SEAWAT.
- Model results indicate an inland migration of the saltwater interface by ~1.5 km (0.9 mi) after 160 years.

Trends in TW Levels at Coastal Structures

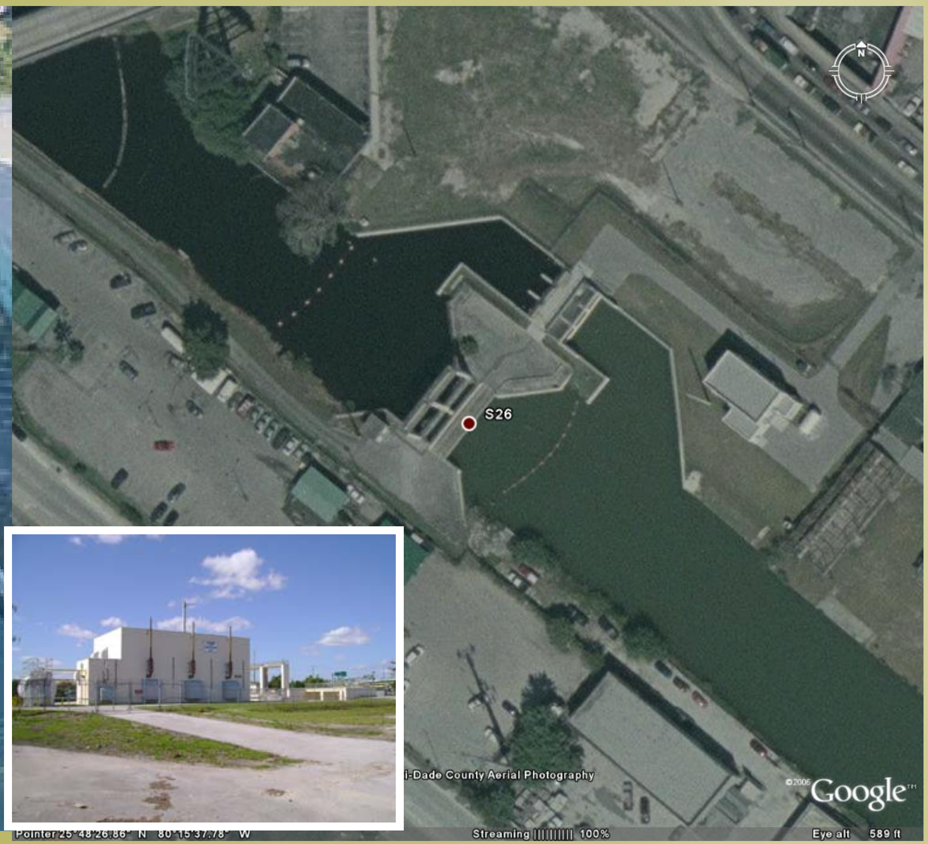
Average trend of 3 mm/yr (1 ft/100 years) is consistent with observed SLR trends



Reductions in Coastal Structure Capacity with SLR



Adaptation – Coastal Structures



Future Work

- **Expert opinion on uncertainties and decision process for climate change scenarios**
- **Extract signal from GCM predictions of the future climate**
- **Apply statistical and dynamical methods for downscaling GCM predictions to local scale**
- **Begin vulnerability assessment on a watershed by watershed basis through the use of regional and local scale hydrologic models driven by local-scale predictions of the future climate**
- **Model impacts of a range of predicted sea level rise on flood control and public water supply**
- **Perform a series of ‘what-if’ adaptation modeling scenarios attempting to minimize collective impacts of climate change on urban, agricultural users and the environment**