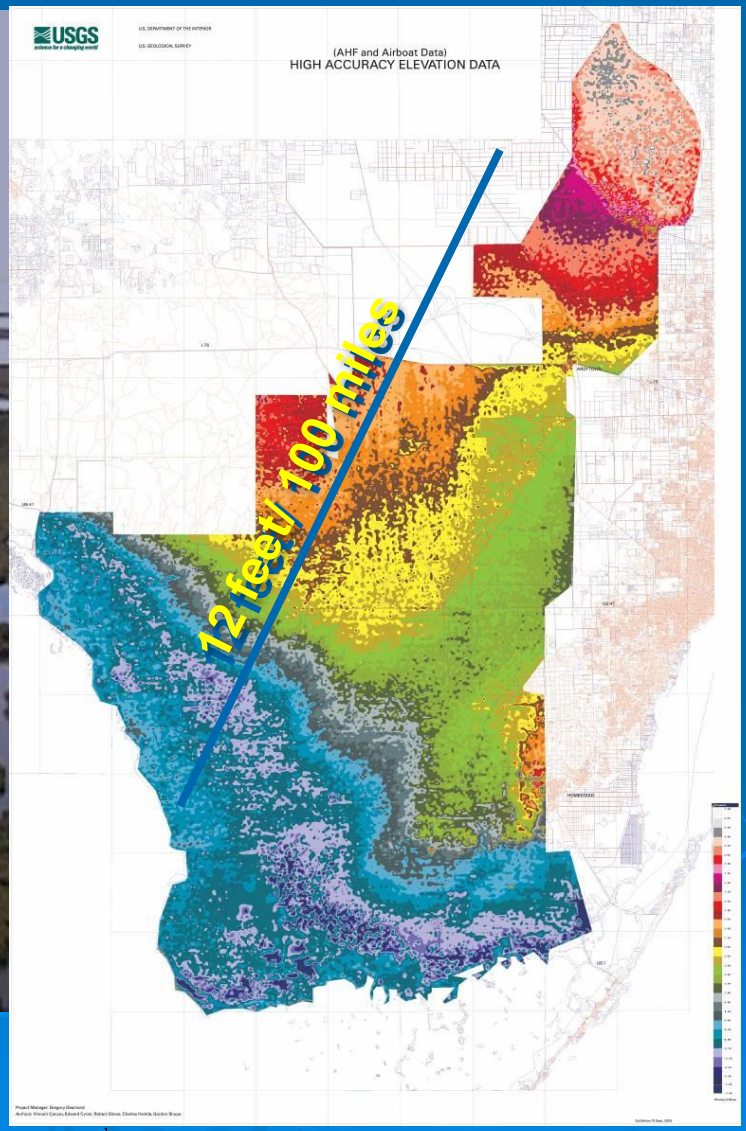
Investigating Hydrologic Scenarios with Climate Change and Ecosystem Process Feedback Using Hindcast and Futurecast Modeling

Eric Swain, Melinda Lohmann, Dennis Krohn, Thomas Smith, Catherine Langtimm, Don DeAngelis, Brad Stith, Jiang Jiang, and Ann Foster

USGS
science for a changing world

Why Hydrodynamic Surface Water Connected to Groundwater?

- Coastal South Florida has very low gradients and multidirectional flows which require the complexity of a hydrodynamic solution
- Coupling to groundwater is essential with the high connectivity of the porous aquifer.
- Computation of salinity and temperature transport needed for ecologic applications



USGS
science for a changing world

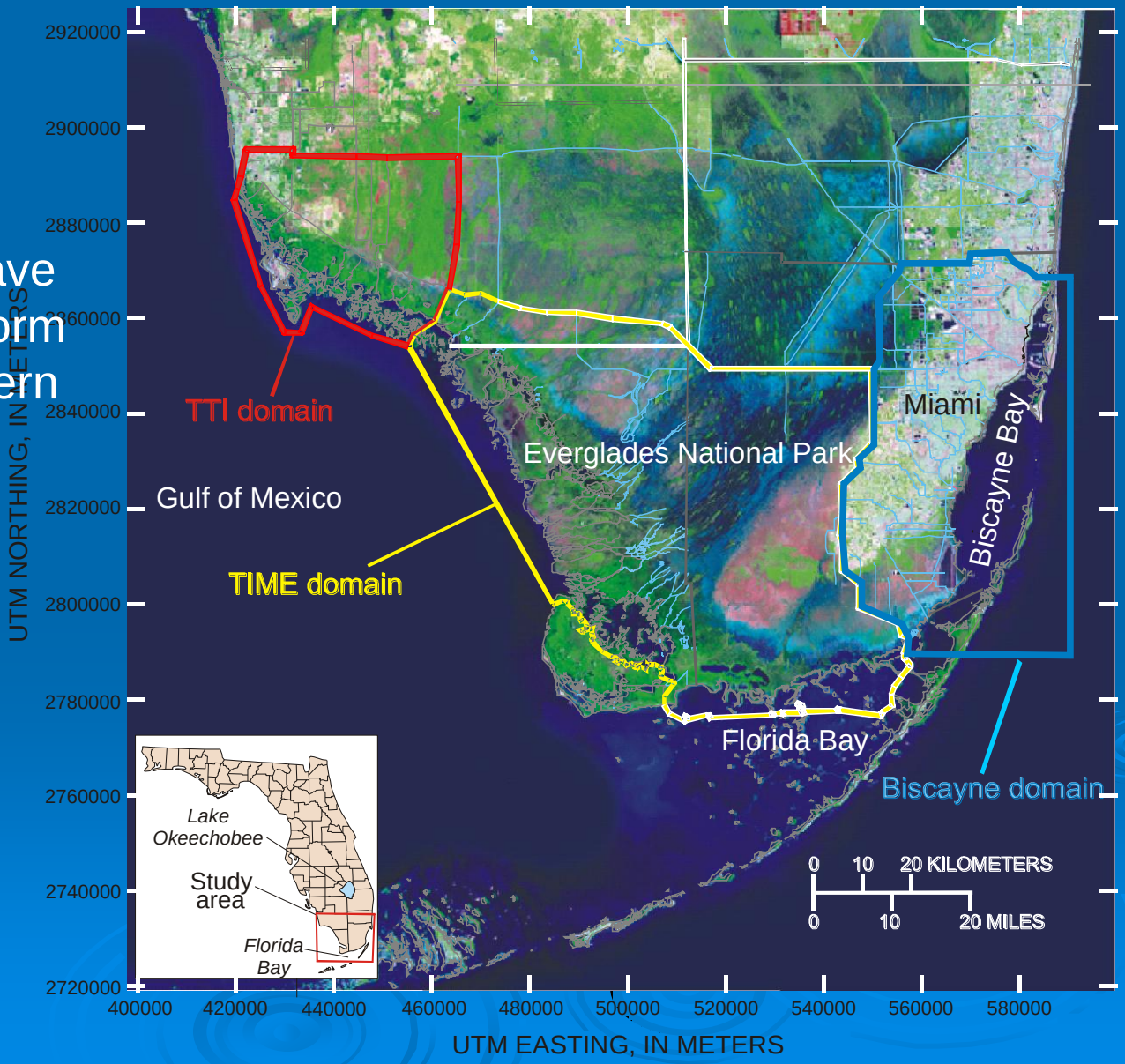
Hydrologic Modeling Tasks

- Develop Hindcast models of recent historic periods
- Represent historic and modern storm events
- Develop futurecast models using downscaled Global Climate Model rainfall
- Utilize historic and modern vegetation/hydrology information to estimate topographic changes

USGS
science for a changing world

South Florida and Model Areas

The TIME and Biscayne models have been combined to form the Biscayne Southern Everglades Coastal Transport (BISECT) model

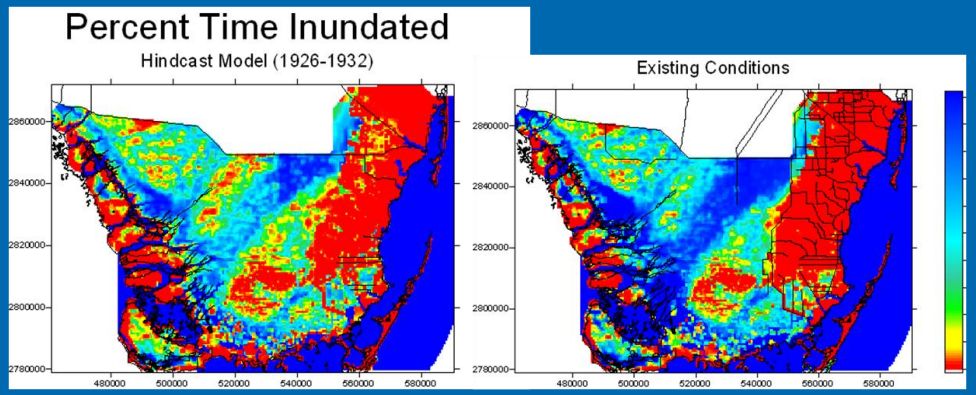


USGS
science for a changing world

Future Impacts of Sea-level rise on Coastal Habitats and Species (FISCHES) team

"Past and Future Impacts of Climate Change on Coastal Habitats and Species in the Everglades: an Integrated Modeling Approach"

Simulate historical period with FTLOADDS model to determine water levels, salinity, and flows and compare with historic aerial photography



Represent historic storms and effects on coastal regimes

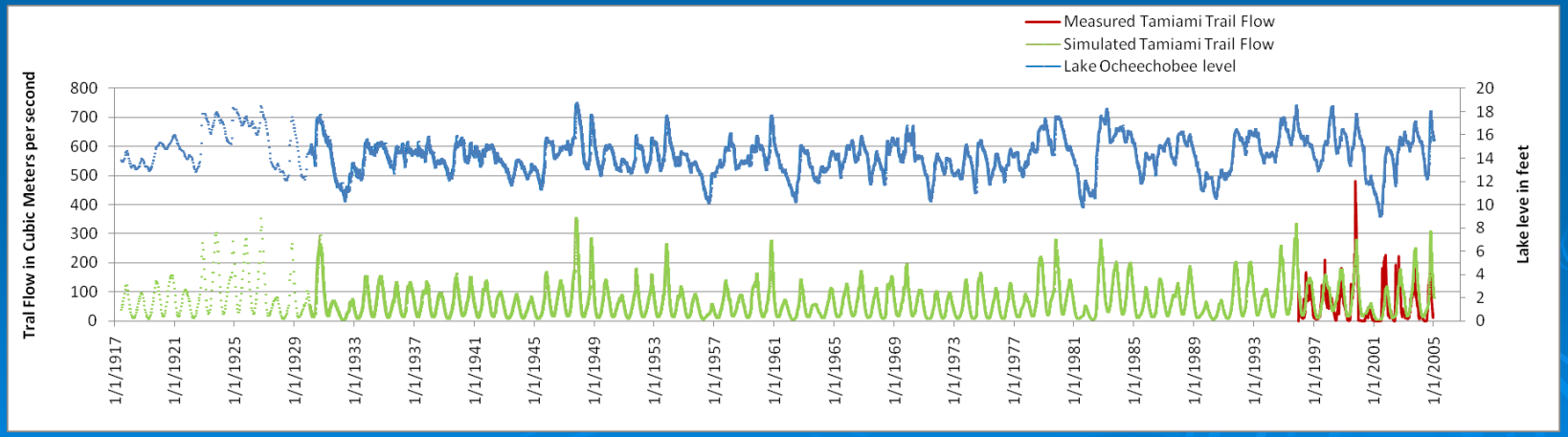
Utilize stochastic technique to determine topographic differences between modern and historic simulations

Mouth of the Little Shark River from 2004 aerial imagery

Data Input for Hindcast BISECT MODEL

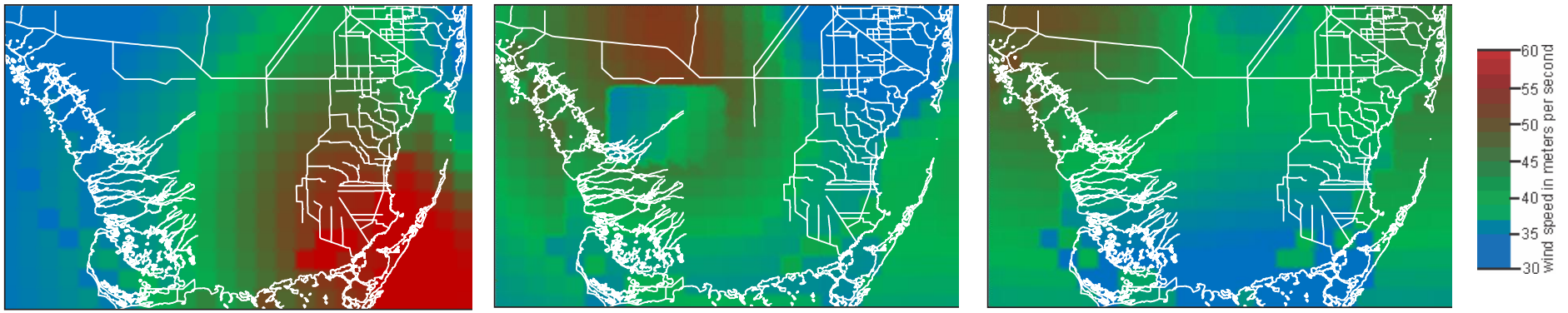
Representing historical periods 1926-1932, 1934-1940, 1996-2002

- Boundary Data
  - Tidal levels adjusted using Key West record
  - Rainfall from historic gages
  - Hurricane events specified individually
  - Basic wind and atmospheric data used from 1996-2002
  - Northern boundary flows synthesized based on Lake Okeechobee



USGS
science for a changing world

Representation of Hurricane Windfields

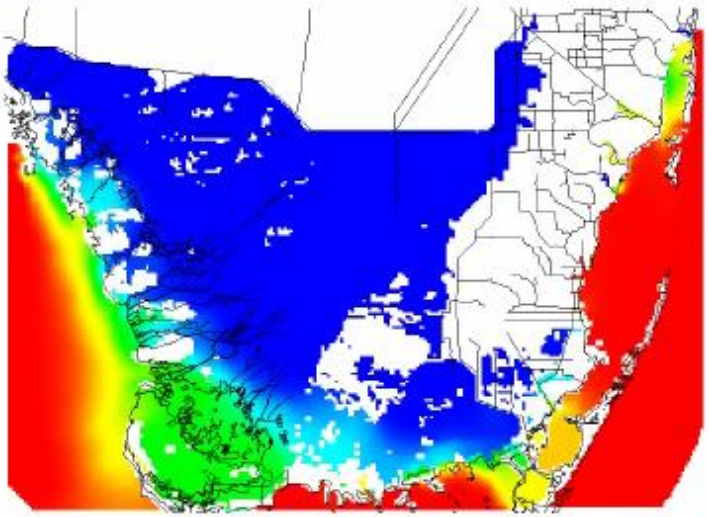


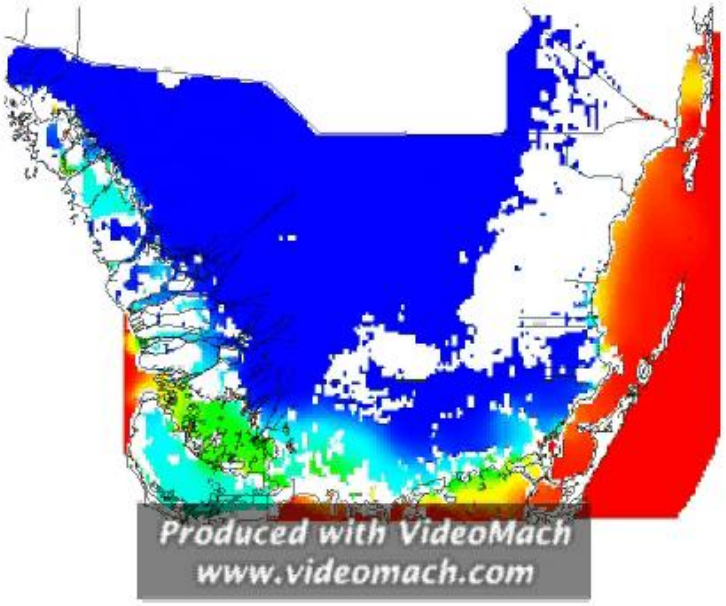
hour 1 hour 2 hour 3

Simulation of 1926 E-W trending Great Miami Hurricane

- Hurricane Wilma reanalysis data scaled and reoriented to provide surrogate windfield data to represent Great Miami Hurricane of 1926
- Windfield in original form used to represent Wilma-type storm striking at different historical times
- Effects of representing the windfield at different spatial resolutions examined

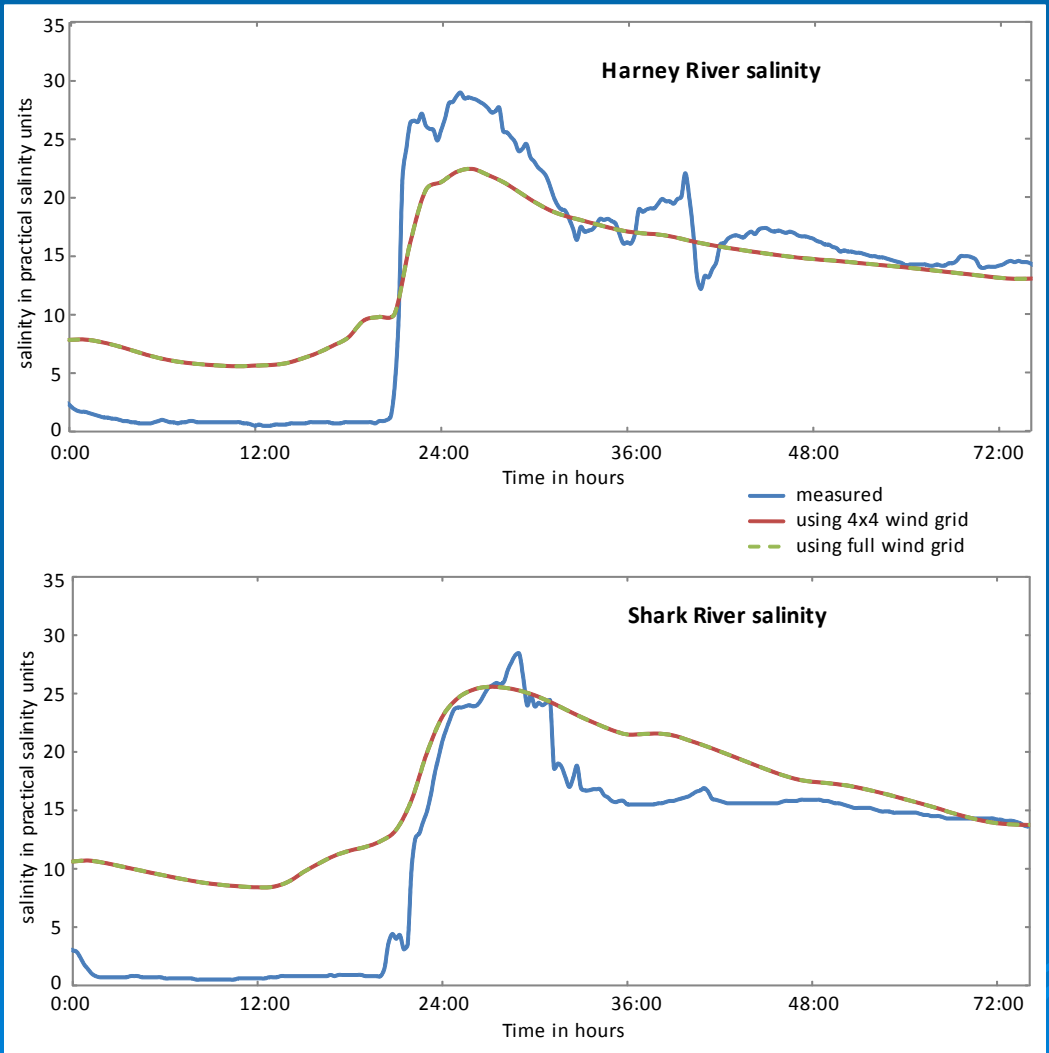
Hurricane Wilma



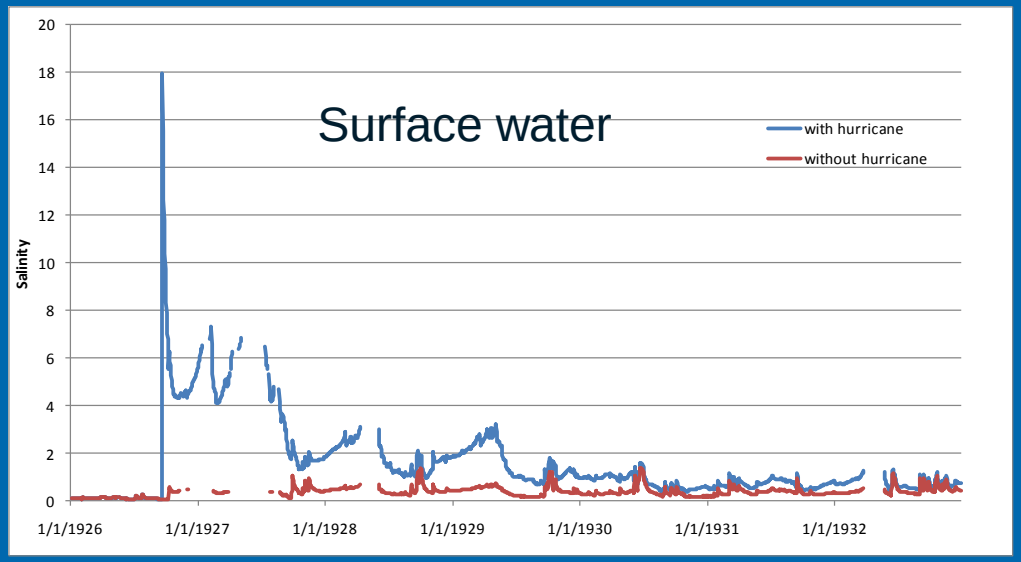


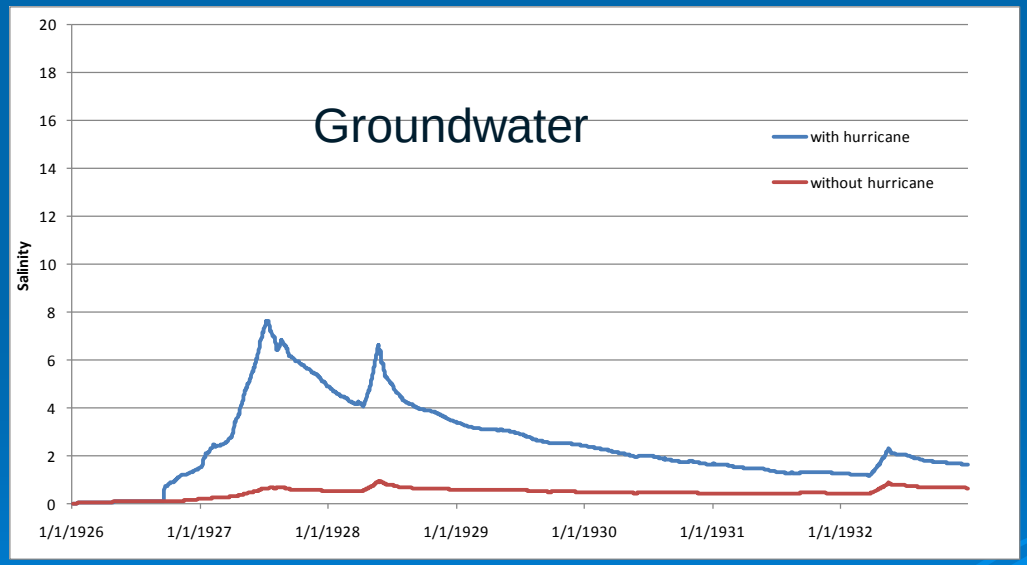
Great Miami Hurricane

Salinity surge and washout matches with field data at coastal creeks.

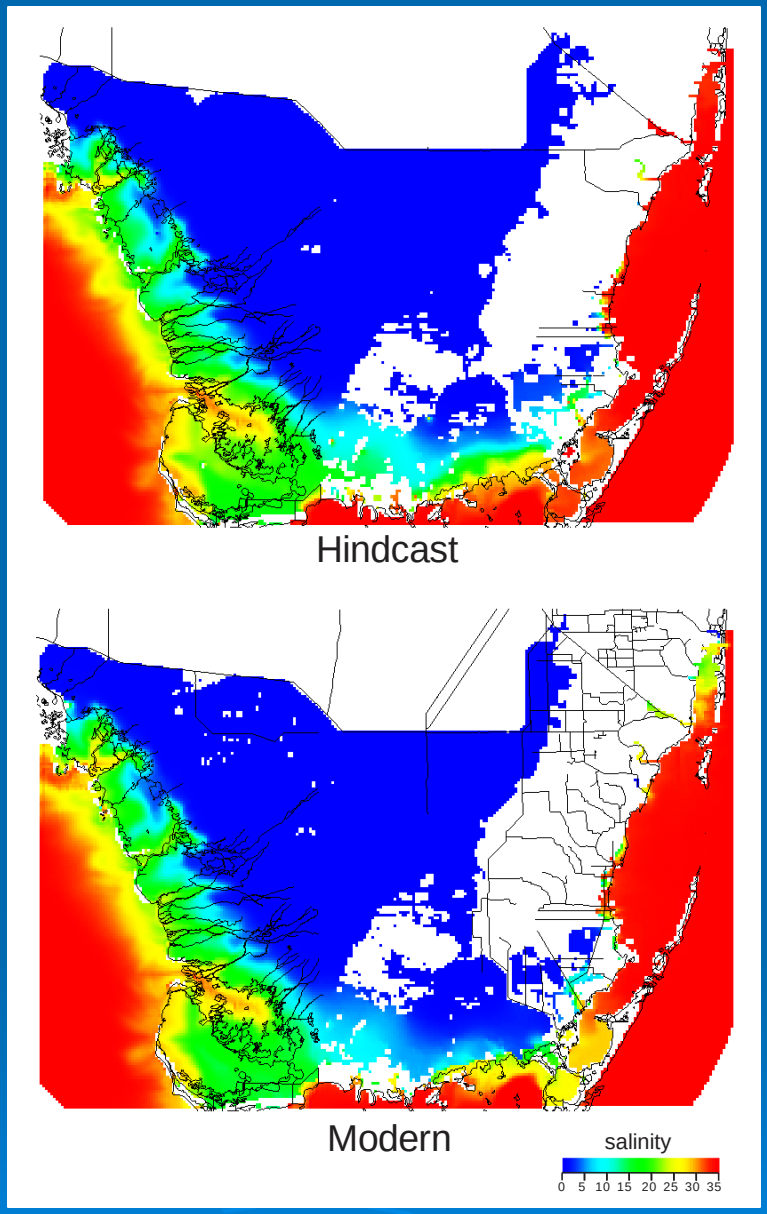


Comparison of "1996 Wilma simulation" of salinity surges to actual 2005 Wilma field measurements

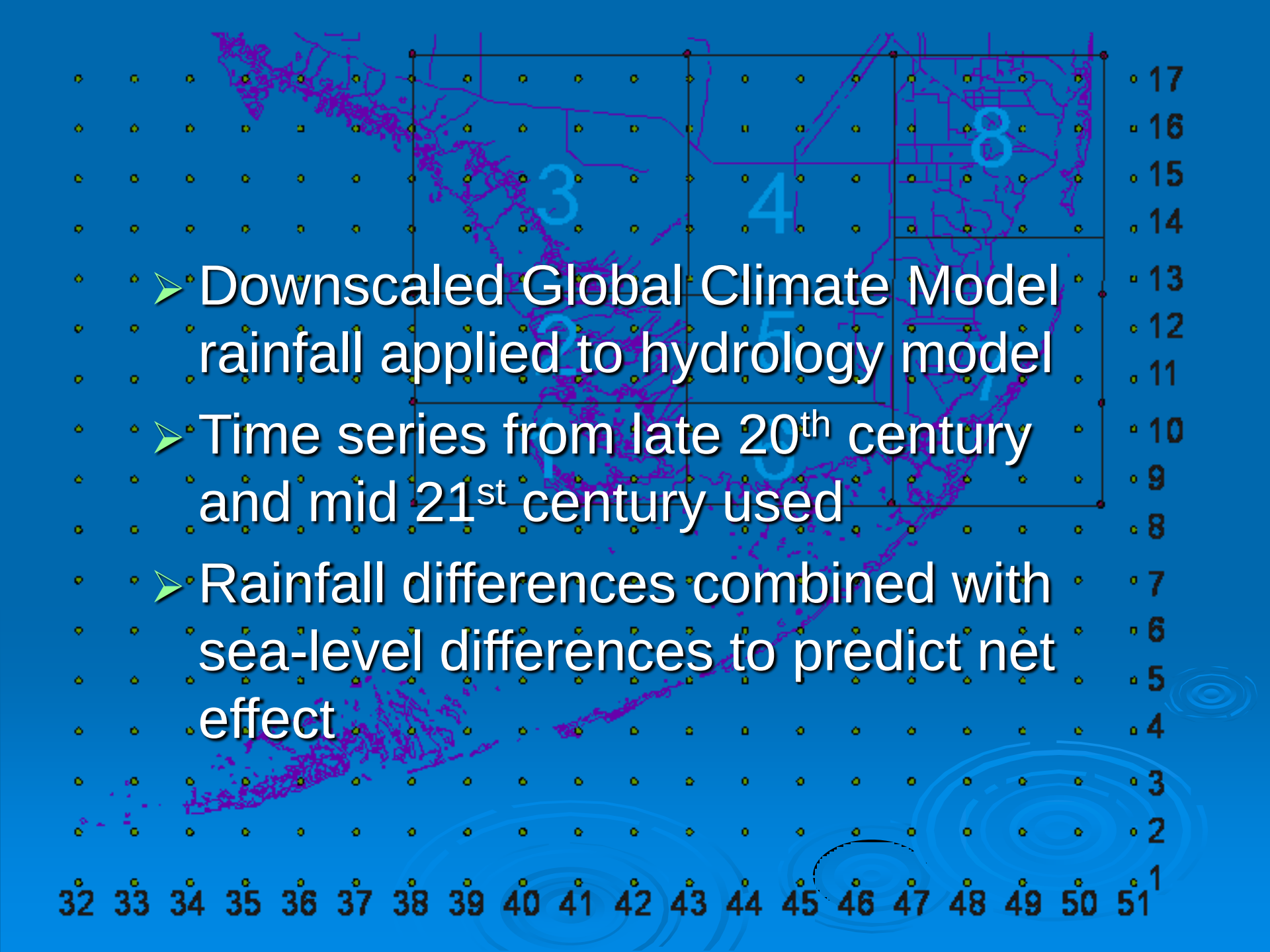




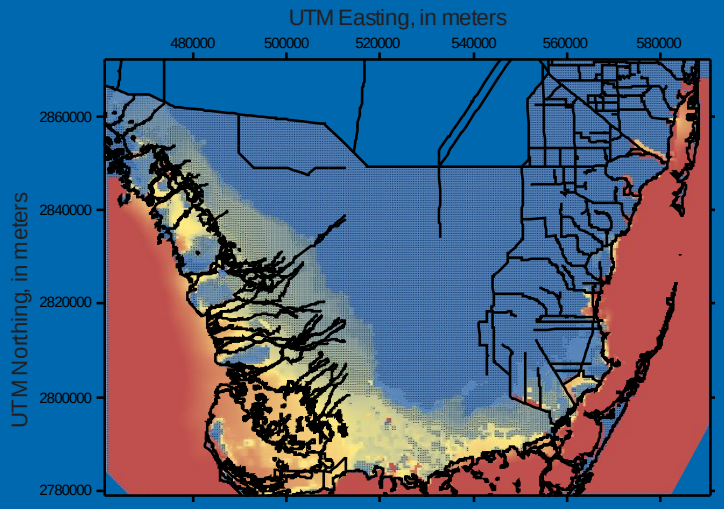
Potential long-term hurricane effect on southeastern isolated wetland.



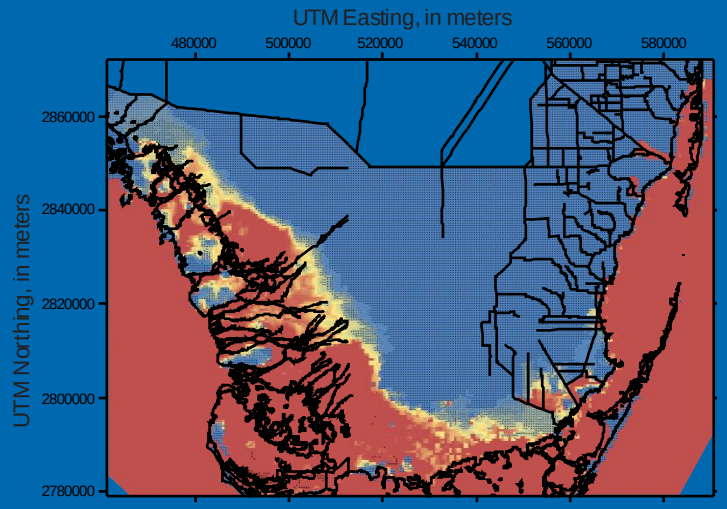
Simulating effects of Wilma-type storm on hindcast hydrology (1926) and recent hydrology (1996).



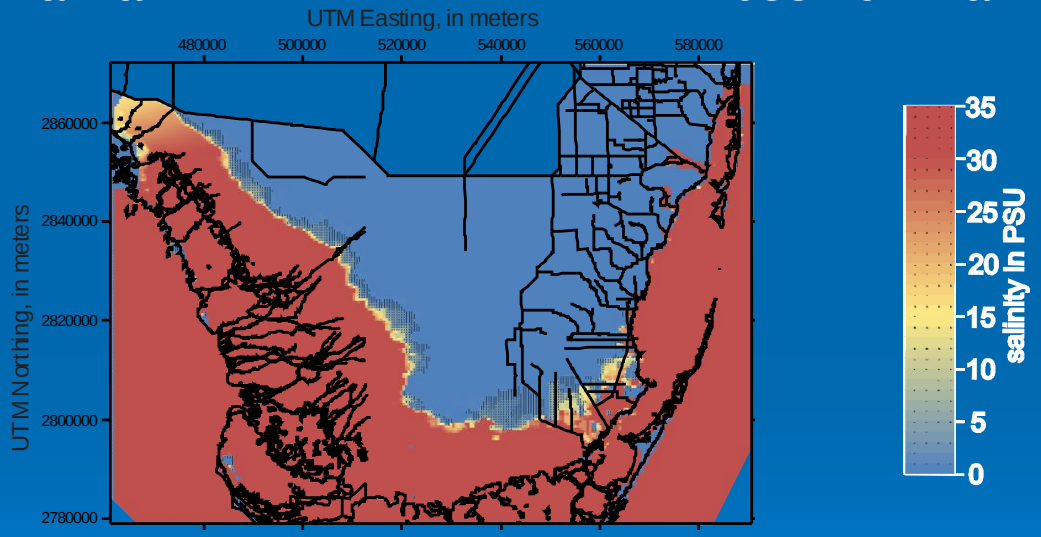
- Downscaled Global Climate Model rainfall applied to hydrology model
- Time series from late 20th century and mid 21st century used
- Rainfall differences combined with sea-level differences to predict net effect



1996-1999 rainfall



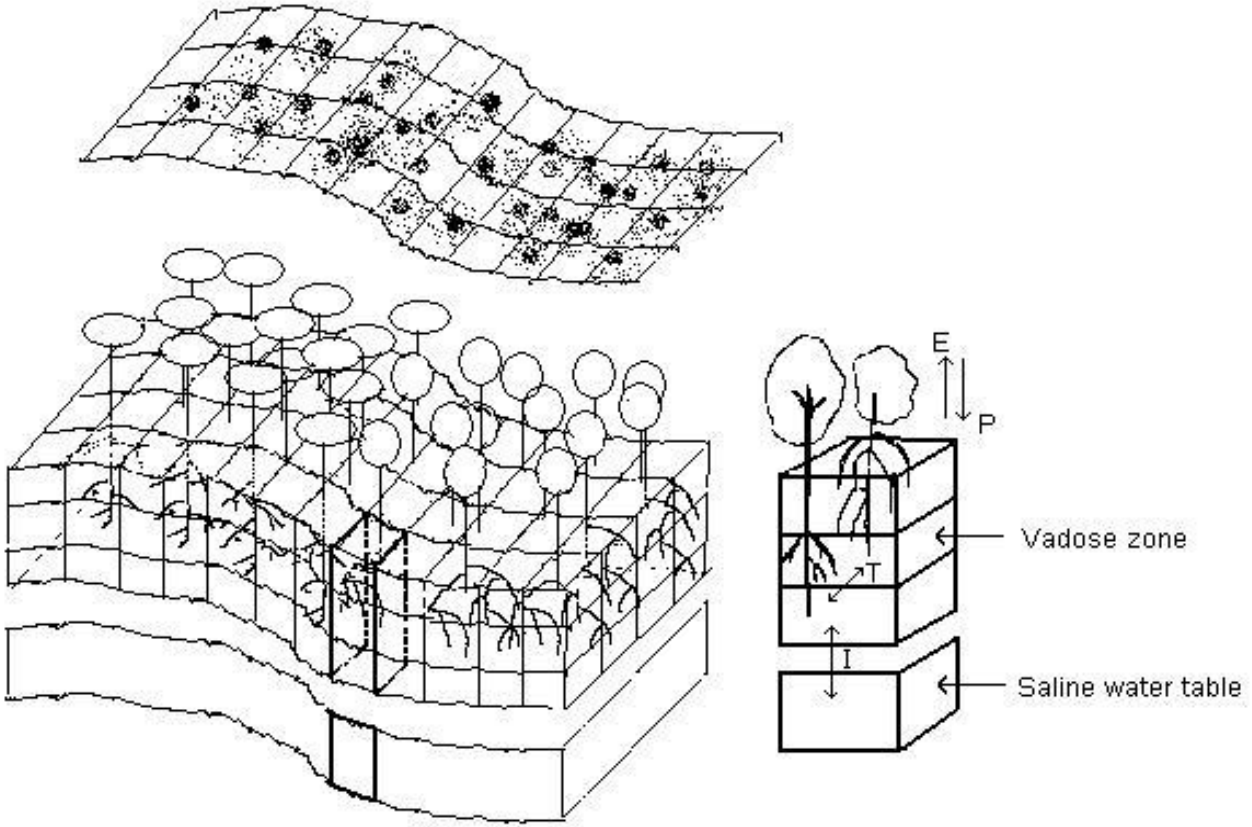
2038-2041 rainfall

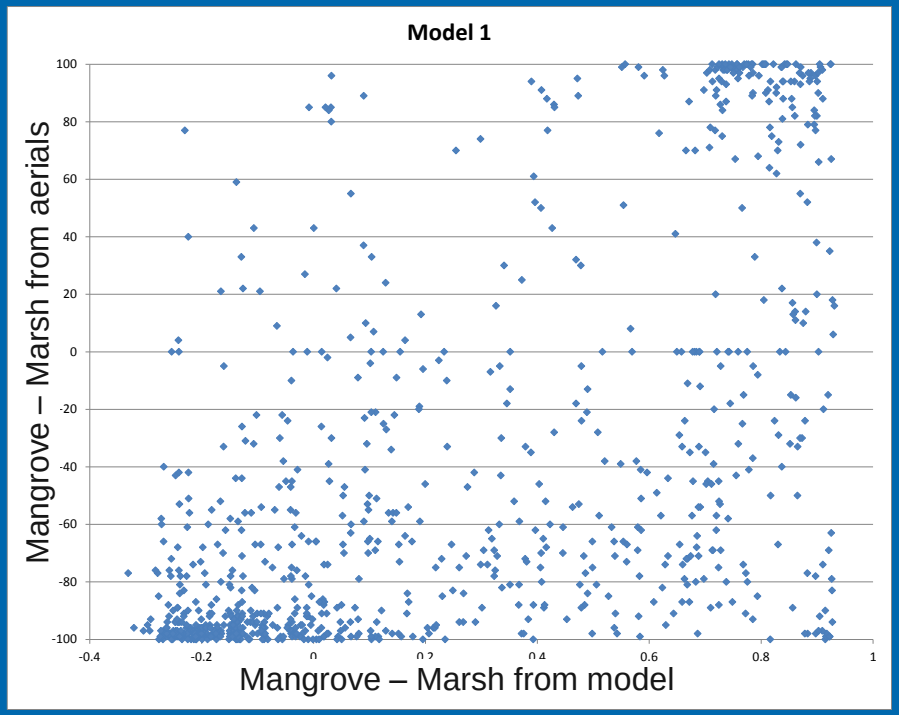


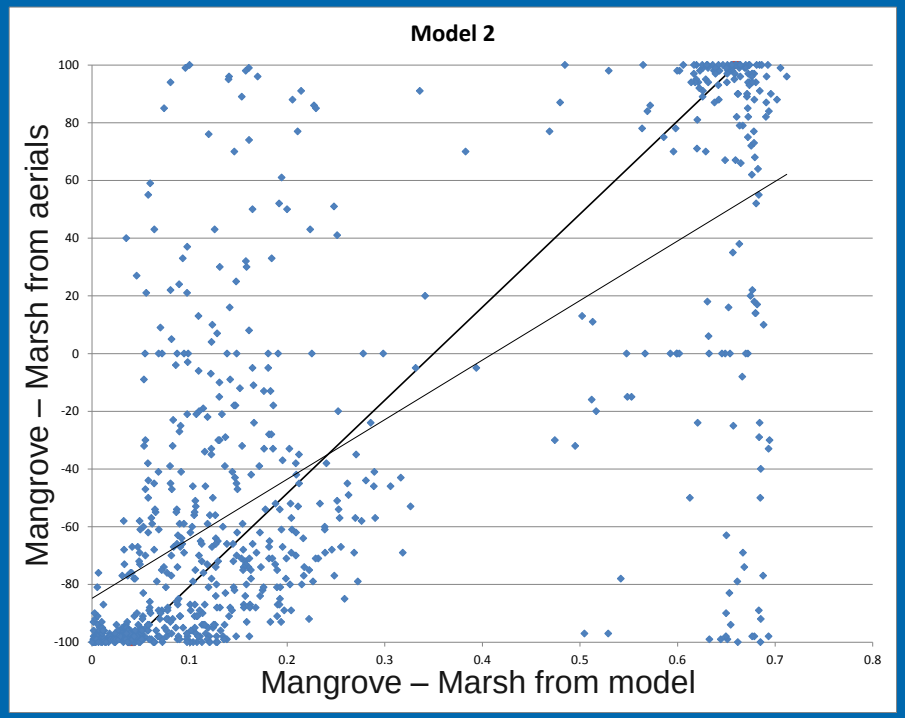
2038-2041 rainfall, 1 foot sea-level rise

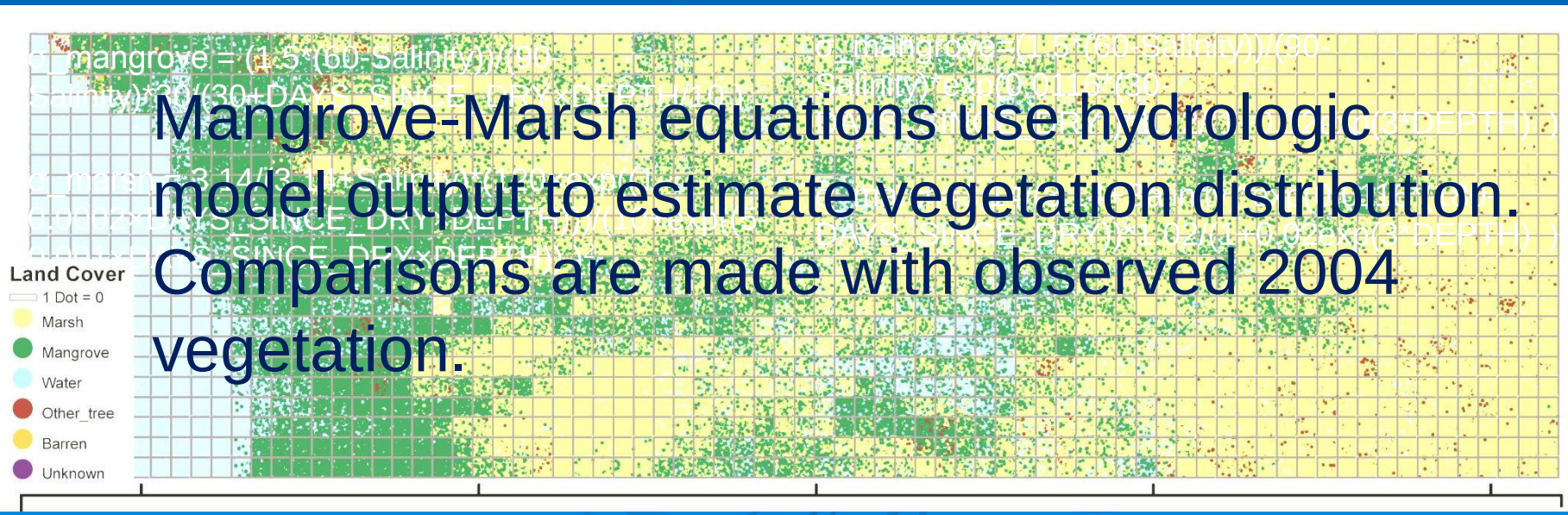
Comparison of average salinity between late 20th century scenario and future rainfall and sea-level rise scenario.

Salinity washed on shore important to Mangrove-Hammock Model

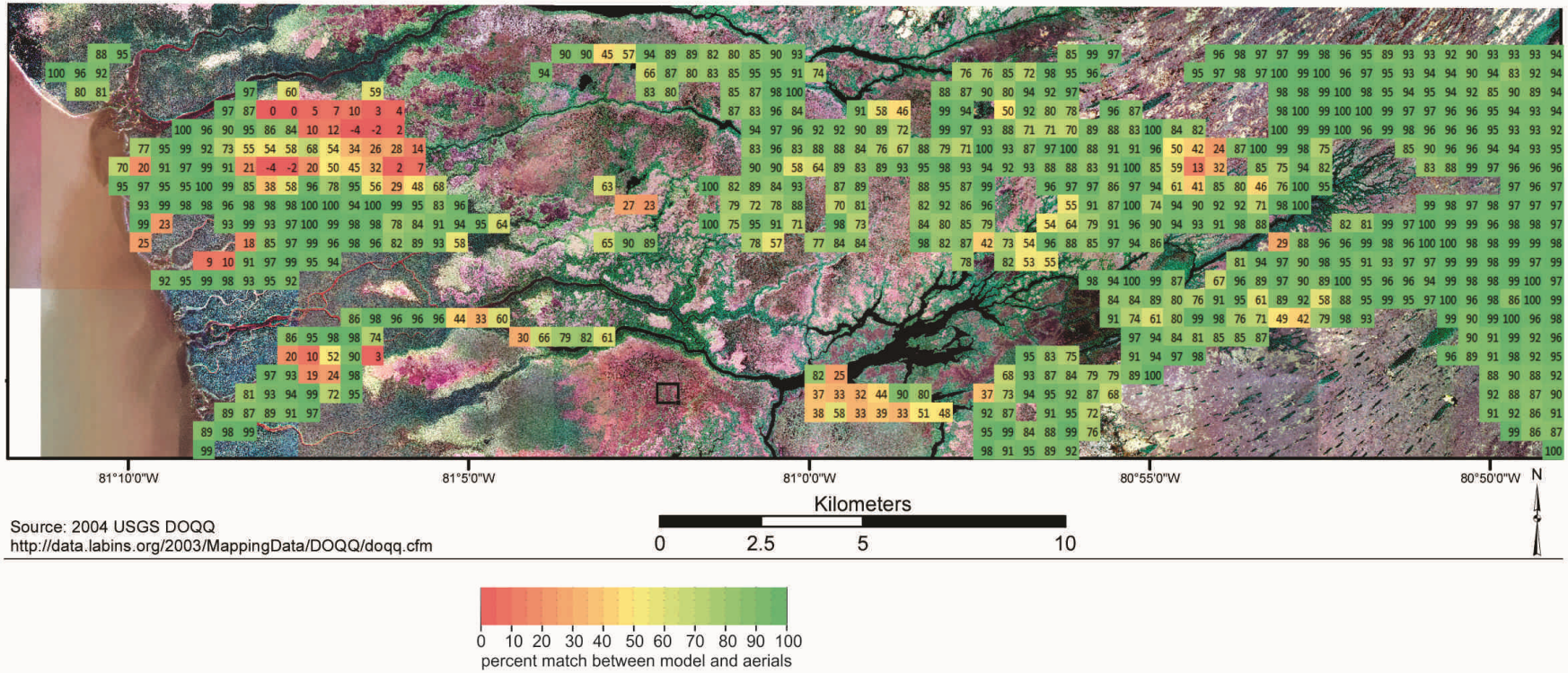








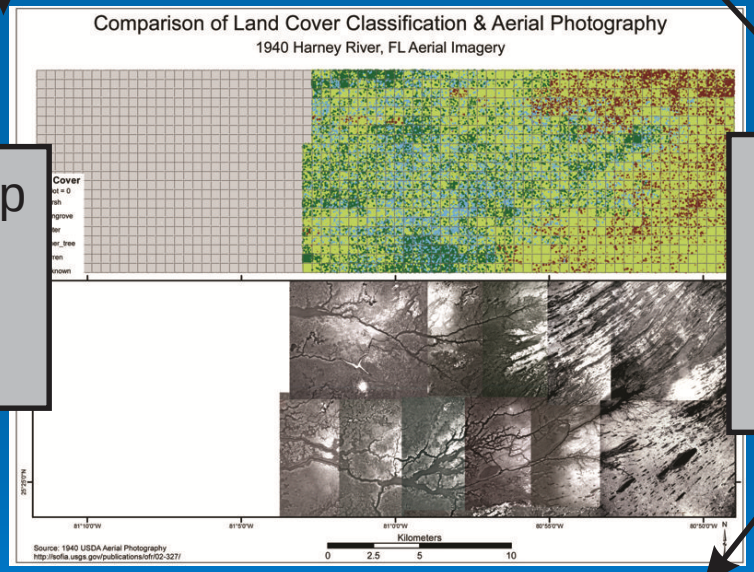
Mangrove-Marsh equations use hydrologic model output to estimate vegetation distribution. Comparisons are made with observed 2004 vegetation.



This map shows how well model-predicted vegetation matches observed vegetation

Parameter estimation with PEST used to estimate land elevation differences using 1940 aerial photography to identify vegetation types

PEST adjusts land elevations based on matching vegetation type



Land elevation adjustments input to FTLOADDS hydrologic model

FTLOADDS hydrologic model computes water-levels and salinity

Model output and relationship of hydrology to vegetation used to compute vegetation types

FUTURE USES OF THE MODELS & RESEARCH

- **Water Supply Issues**
  - *Seawater encroachment effect on wellfields*
  - *Loss of coastal discharge capacities*
- **Understanding climate change and effects to organisms**
  - *Sea level rise*
  - *Temperature increases*
  - *Precipitation changes*
- **Understanding hurricane effects on hydrologic processes and resulting damage to habitats and other parameters that may impact organisms**
  - *Before and after models to identify mechanisms and assess resilience of populations to storm events*
  - *Effects of potential future storm scenarios*

USGS
science for a changing world

USGS FISCHES Team and Collaborating Scientists

- **USGS Gainesville**
  - Catherine Langtimm
  - Brad Stith
  - Ann Foster
- **USGS Fort Lauderdale**
  - Eric Swain
  - Melinda Lohmann
  - Jeremy Decker
- **USGS St. Petersburg**
  - Dennis Krohn
  - Tom Smith
- **University of Miami**
  - Don DeAngelis
  - Jiang Jiang

- **Collaborating Scientists**
  - Rafa Munez and Stuart Miller, UF
  - John Hamrick, Tetratech
  - Glenn Landers, Russ Weeks, Jessica Files, USACE
  - Jayantha Obeysekera, SFWMD
  - Kiren Bahm, Robert Fennema, Ed Kearns, Dewitt Smith, ENP
  - Michael Swain, University of Miami
  - Matthew Swain, Analytical Technologies Inc.

USGS
science for a changing world