Estimation and Prediction of Coastal Landscape Changes Utilizing a Hydrodynamic Simulator and Aerial Photogrammetry

Eric Swain, Catherine Langtimm, Melinda Lohmann, Tom Smith, Dennis Krohn, Don Deangelis, Jeremy Decker, and Brad Stith

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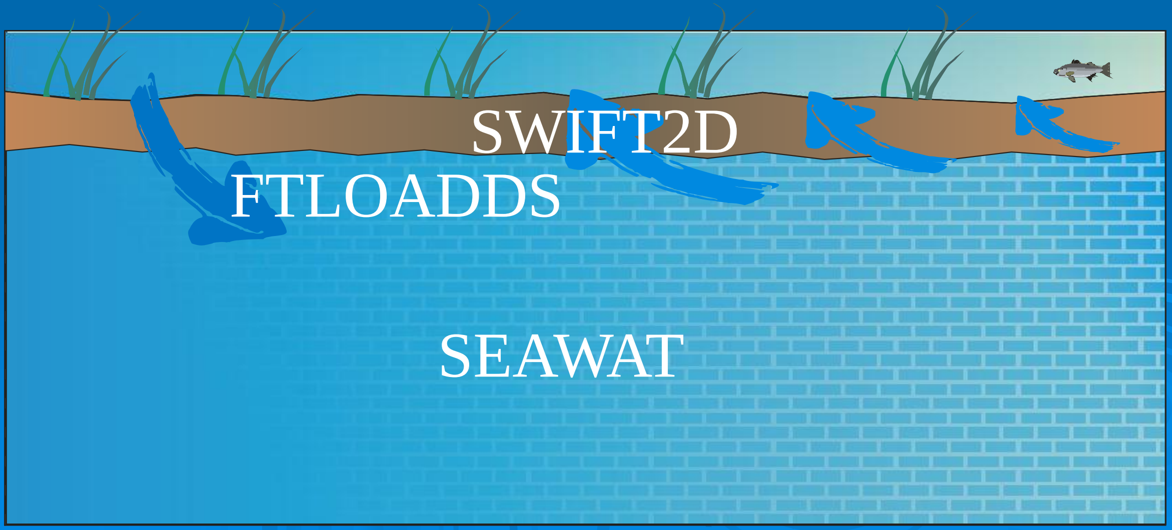
Coupled Hydrodynamic SW/GW

- FTLOADDS (Flow and Transport in a Linked Overland/Aquifer Density Dependent System) Useful to look at water management because:
  - **SWIFT2D is a two-dimensional hydrodynamic surface-water model**
  - **SEAWAT is a three-dimensional ground-water flow model**
  - **Salinity transport is accounted for in both surface water and ground water**



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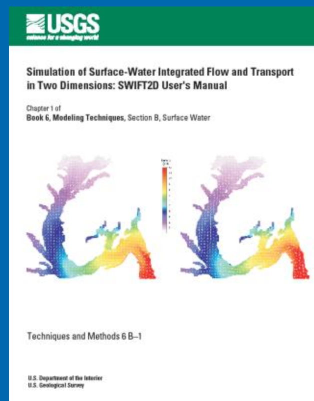
MODELING SUITE

SWIFT2D



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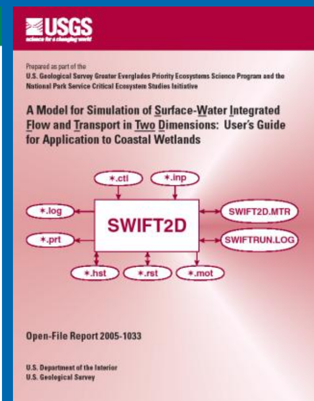
Simulation of Surface-Water Integrated Flow and Transport in Two Dimensions: SWIFT2D User's Manual

Chapter 1 of
Book 6, Modeling Techniques, Section B, Surface Water

Techniques and Methods 6 B–1

U.S. Department of the Interior
U.S. Geological Survey



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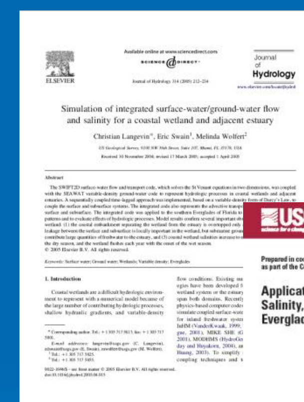
Prepared as part of the
U.S. Geological Survey Greater Everglades Priority Ecosystems Science Program and the National Park Service Critical Ecosystem Studies Initiative

A Model for Simulation of Surface-Water Integrated Flow and Transport in Two Dimensions: User's Guide for Application to Coastal Wetlands

Open-File Report 2005-1033

U.S. Department of the Interior
U.S. Geological Survey

FTLOADDS



Available online at www.sciencedirect.com

ELSEVIER

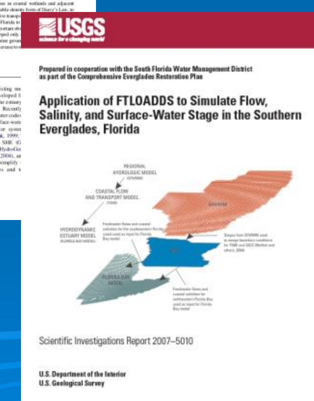
Journal of Hydrology

Simulation of integrated surface-water/ground-water flow and salinity for a coastal wetland and adjacent estuary

Christian Langevin, Eric Swain, Melinda Wolfert

Abstract

1. Introduction



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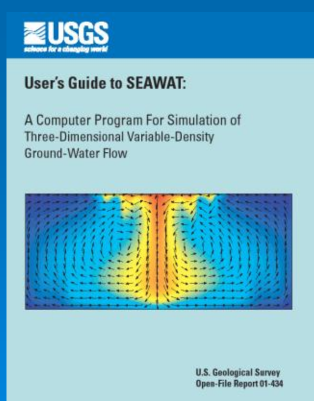
Prepared in cooperation with the South Florida Water Management District as part of the Comprehensive Everglades Restoration Plan

Application of FTLOADDS to Simulate Flow, Salinity, and Surface-Water Stage in the Southern Everglades, Florida

Scientific Investigations Report 2007–5010

U.S. Department of the Interior
U.S. Geological Survey

SEAWAT



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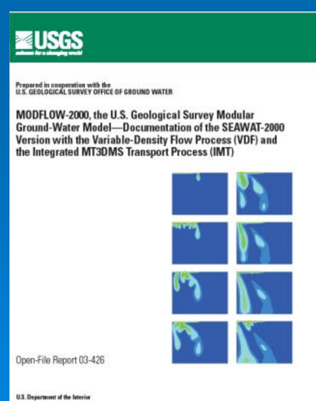
User's Guide to SEAWAT:

A Computer Program For Simulation of Three-Dimensional Variable-Density Ground-Water Flow

U.S. Geological Survey
Open-File Report 01-434



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Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY OFFICE OF GROUND WATER

MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model—Documentation of the SEAWAT-2000 Version with the Variable-Density Flow Process (VDF) and the Integrated MT3DMS Transport Process (IMT)

Open-File Report 03-426

U.S. Department of the Interior
U.S. Geological Survey

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SEAWAT Version 4:

A Computer Program for Simulation of

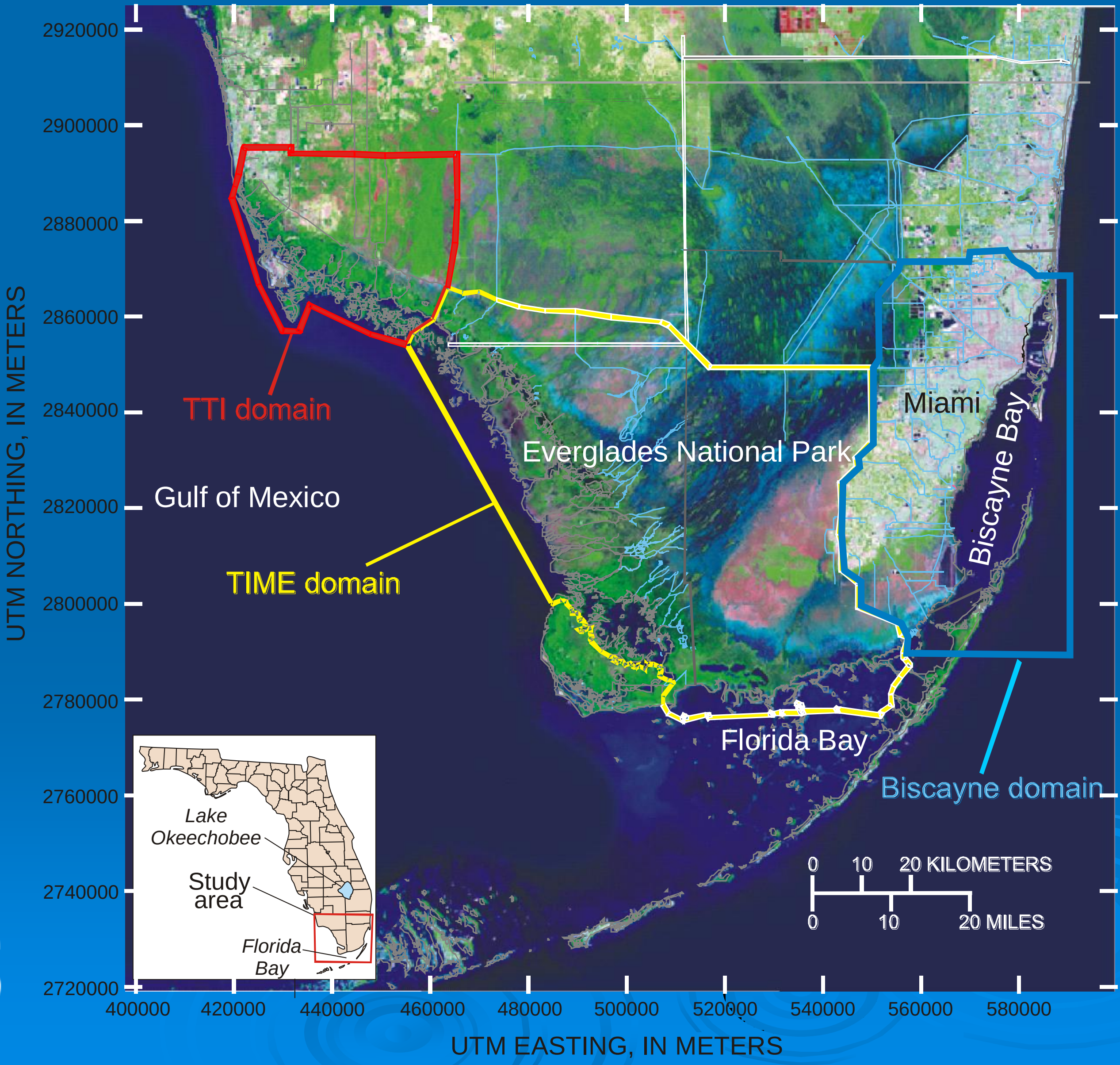
Multi-Species Solute and Heat Transport

By Christian D. Langevin, Danny Thorne, Alyssa M. Dausman, Michael C. Sukop, and Weixing Guo

Open-File Report 2007-XXXX

U.S. Department of the Interior
U.S. Geological Survey

South Florida and Model Areas



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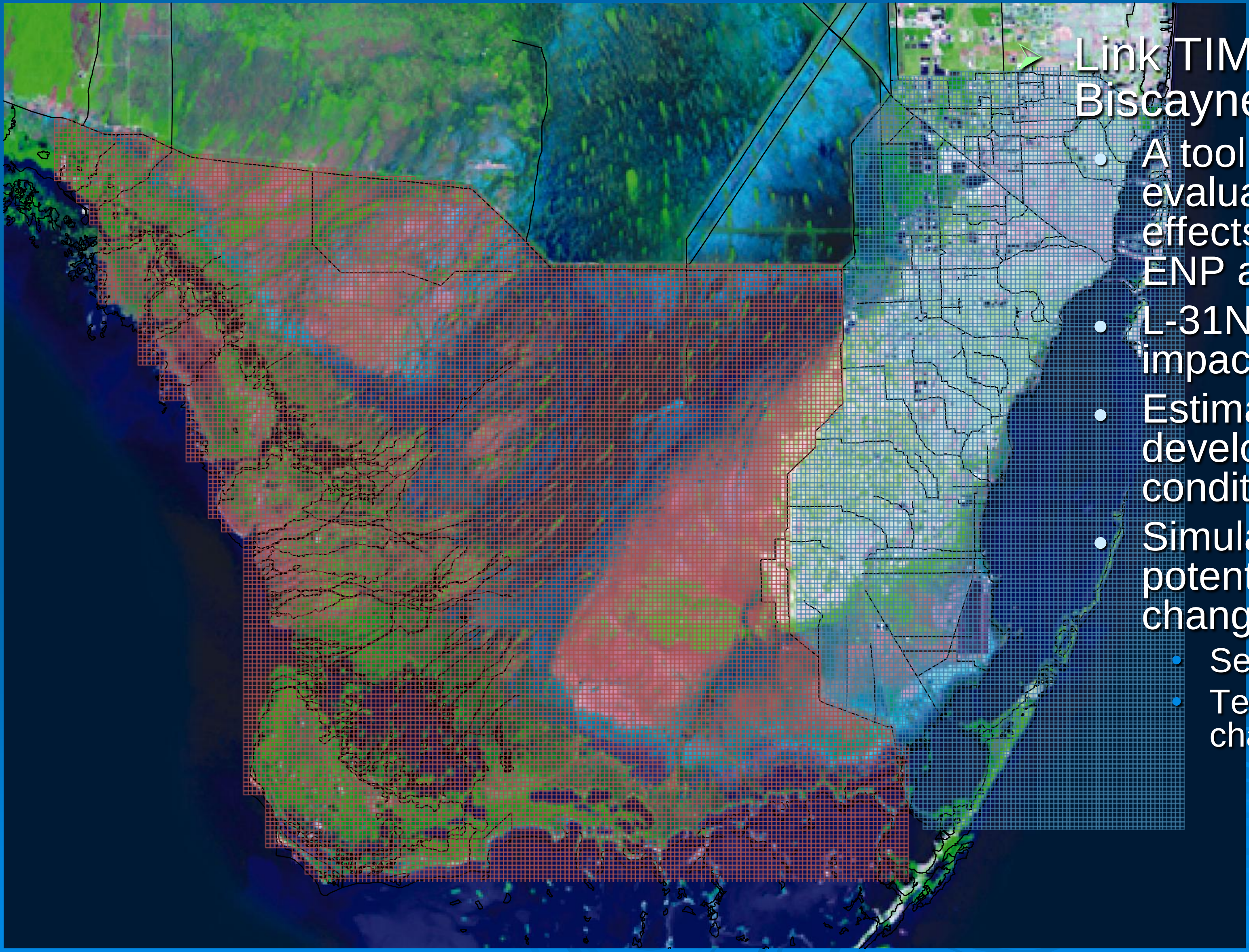
COMBINED MODEL AREA

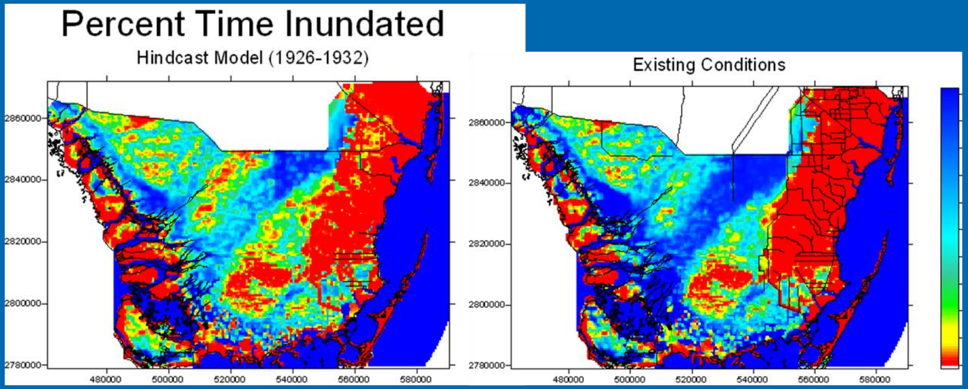
BIscayne Southern Everglades Coastal Transport (BISECT) model



- Link TIME and Biscayne Models
  - A tool to evaluate CERP effects on both ENP and BNP
  - L-31N/ C-111 impact on GW
  - Estimate Pre-development conditions
  - Simulate potential climate change
    - Sea-level rise
    - Temperature change

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

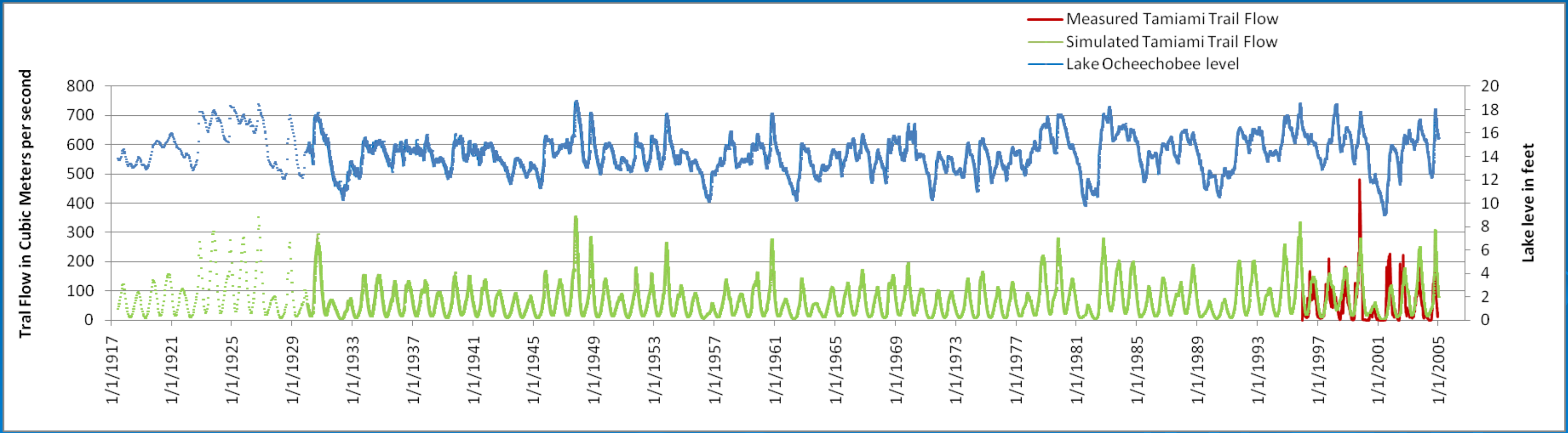
Mouth of the Little Shark River from 2004 aerial imagery

Data Input for Hindcast BISECT MODEL
Representing historical periods
1926-1932, 1934-1940, 1946-1952

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

Tamiami Trail flows related to Lake Okeechobee levels

- Lake Okeechobee water-level record back to 1917
- Best fit function uses a Fourier series for the seasonal fluctuations and amplitude a function of Lake levels



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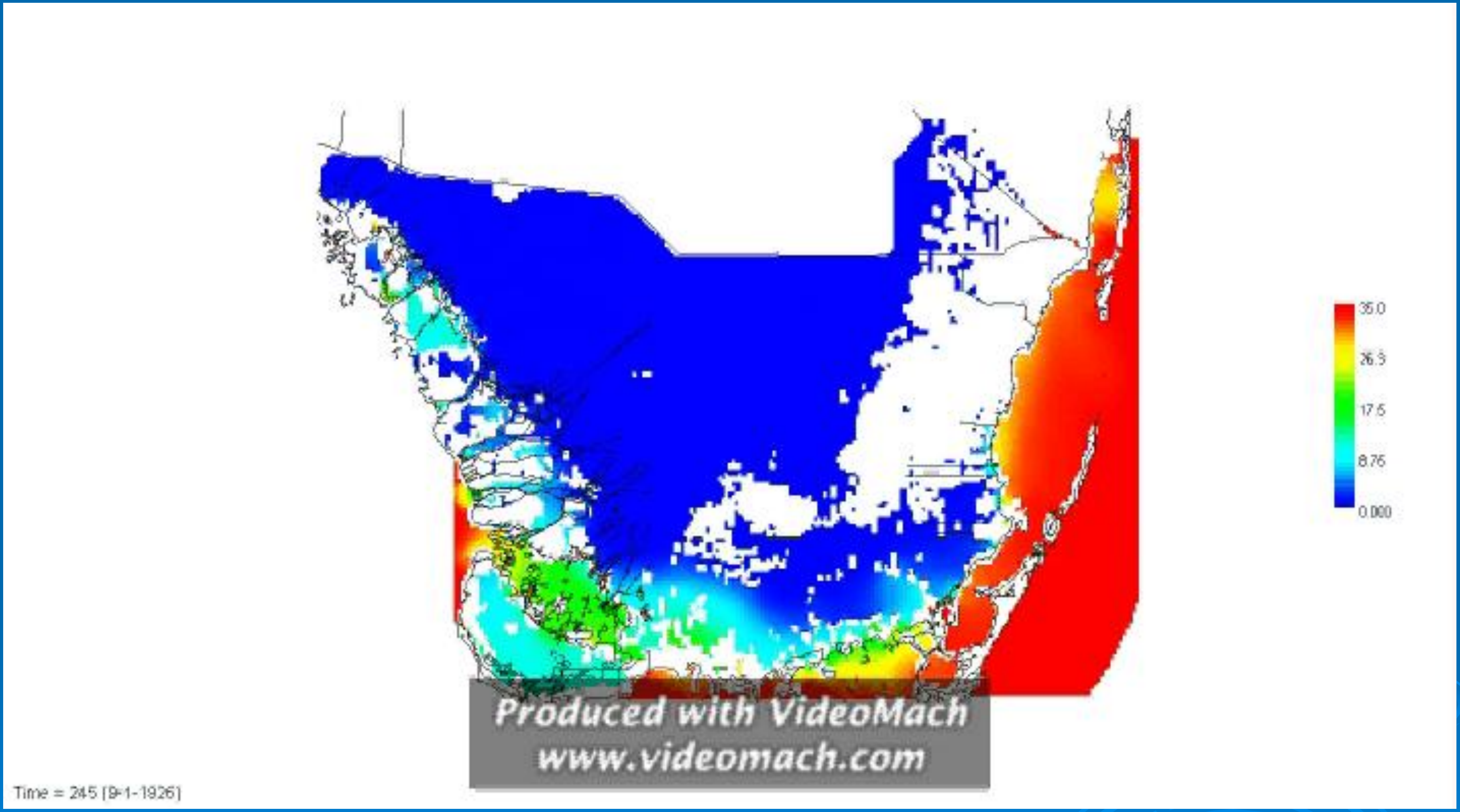
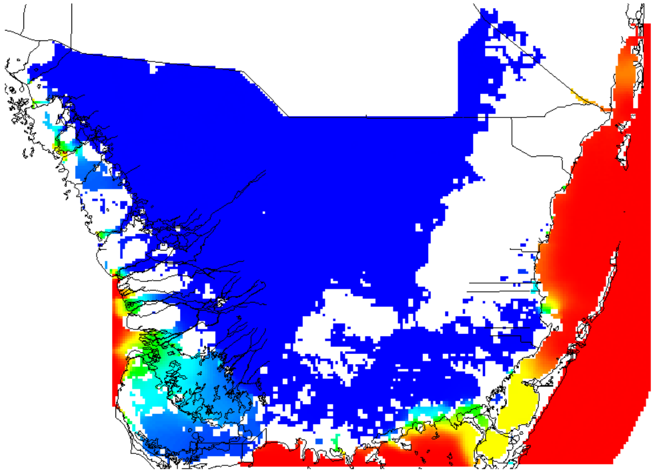
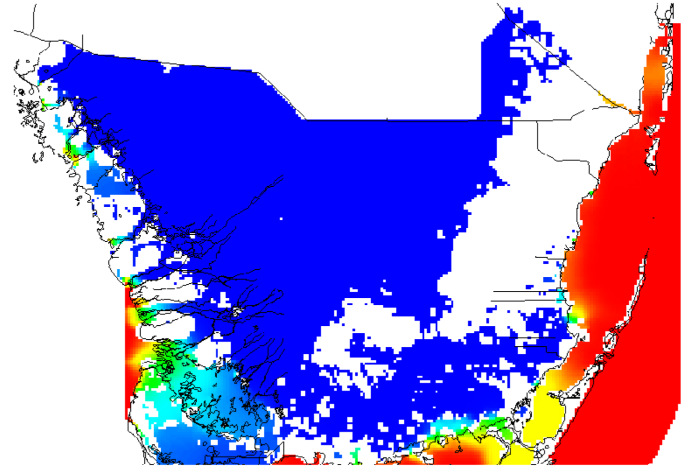


1925 Great Miami Hurricane

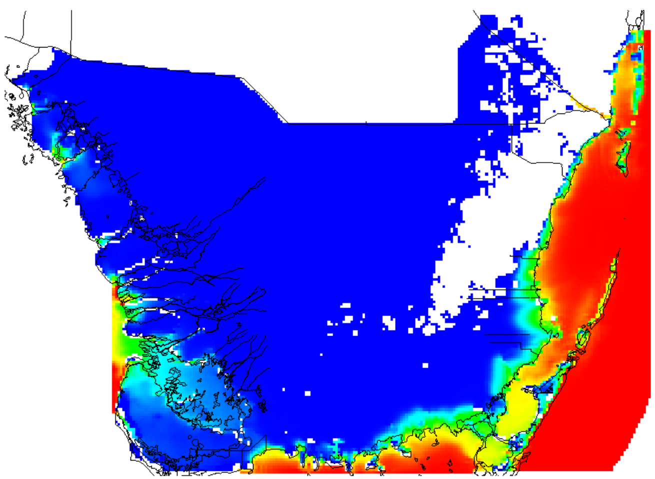
with hurricane

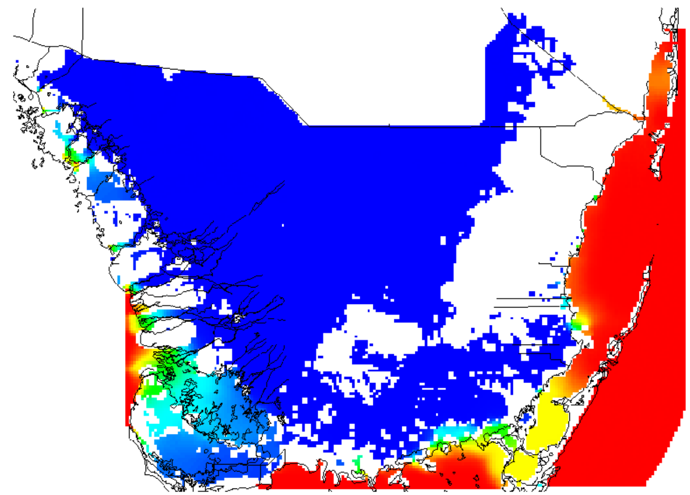
without hurricance



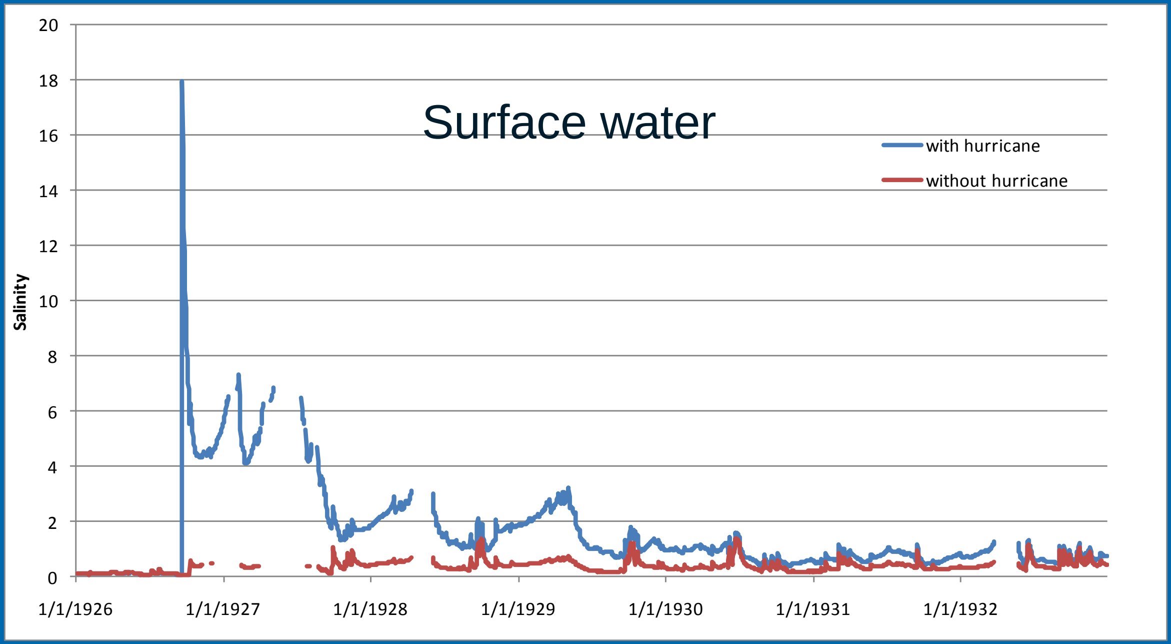


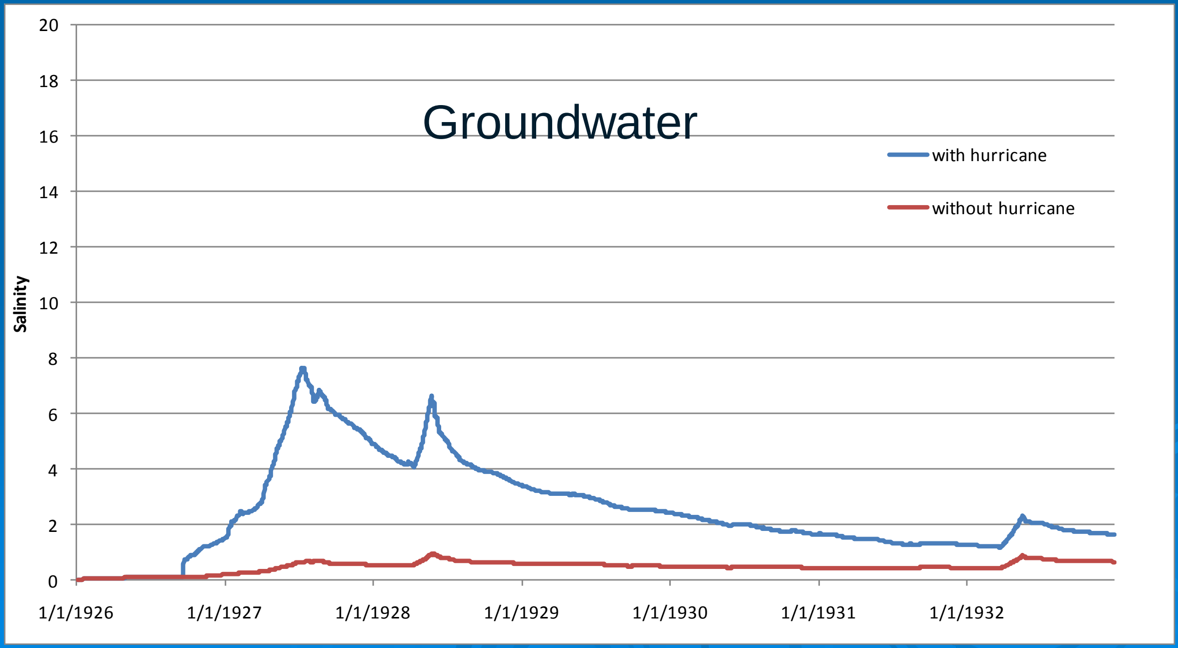
9/17/1926



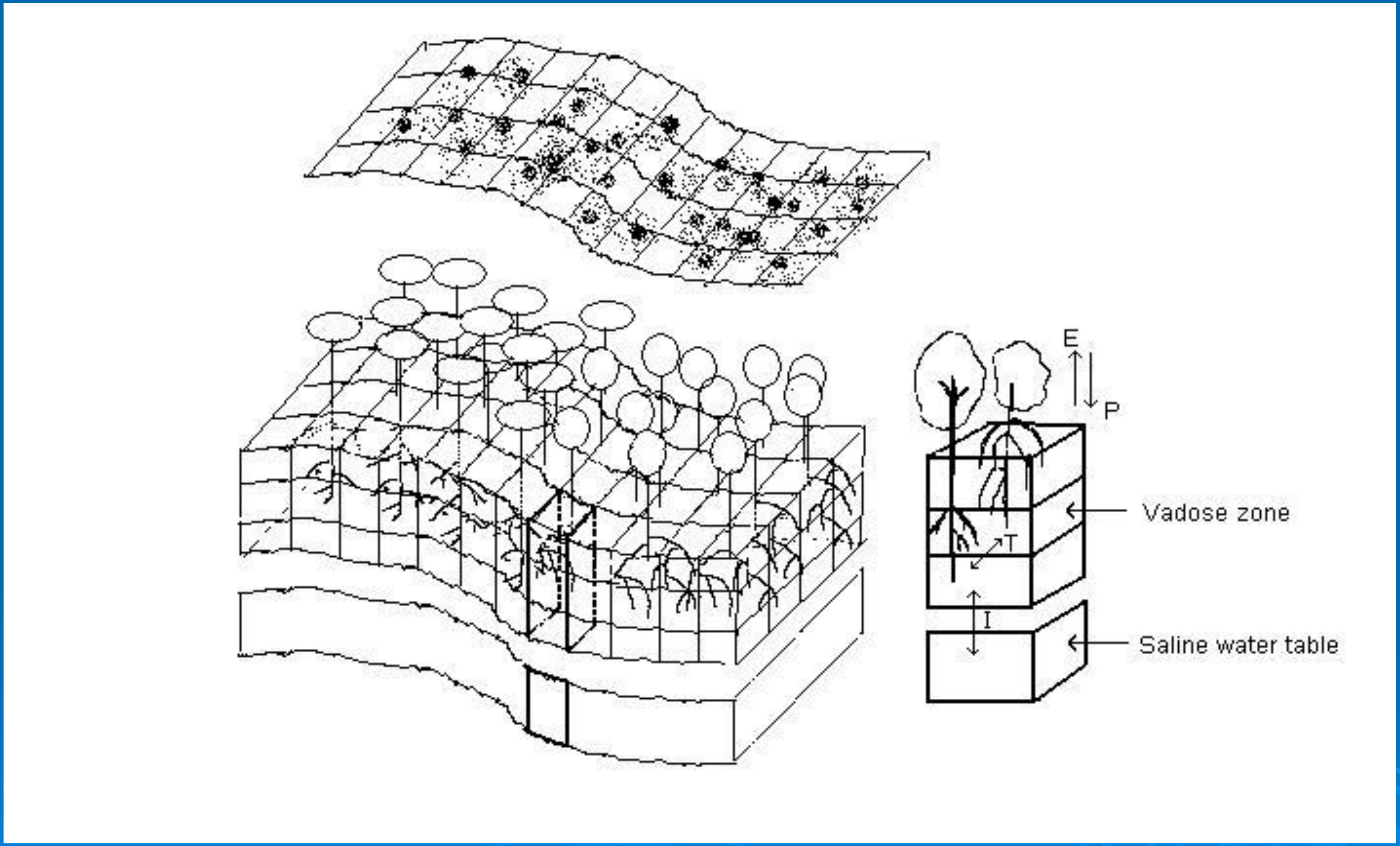


9/18/1926


Surface water
with hurricane
without hurricane
Salinity
20
18
16
14
12
10
8
6
4
2
0
1/1/1926
1/1/1927
1/1/1928
1/1/1929
1/1/1930
1/1/1931
1/1/1932


Groundwater
with hurricane
without hurricane
Salinity
20
18
16
14
12
10
8
6
4
2
0
1/1/1926
1/1/1927
1/1/1928
1/1/1929
1/1/1930
1/1/1931
1/1/1932

Salinity washed on shore important to Mangrove-Hammock Model

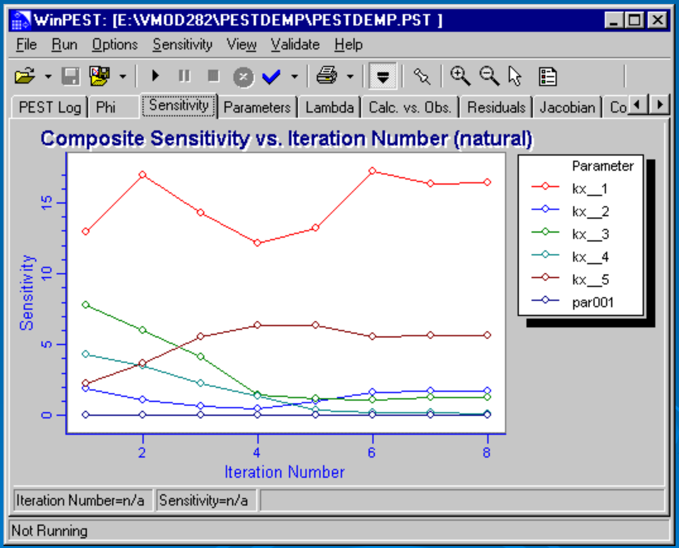


Changes in coastal topography

- Coastal changes can occur from storm buildup, soil accretion and erosion, and the effects of seal-level changes.
- Coastal changes affect inundation and salinity, reflected in vegetation.

PEST parameter estimation and Hindcast modeling

- PEST is used to determine the effects on model output of variations in model input
- PEST is applied to the Hindcast model to adjust local topography values to match historic hydroperiod or salinity information



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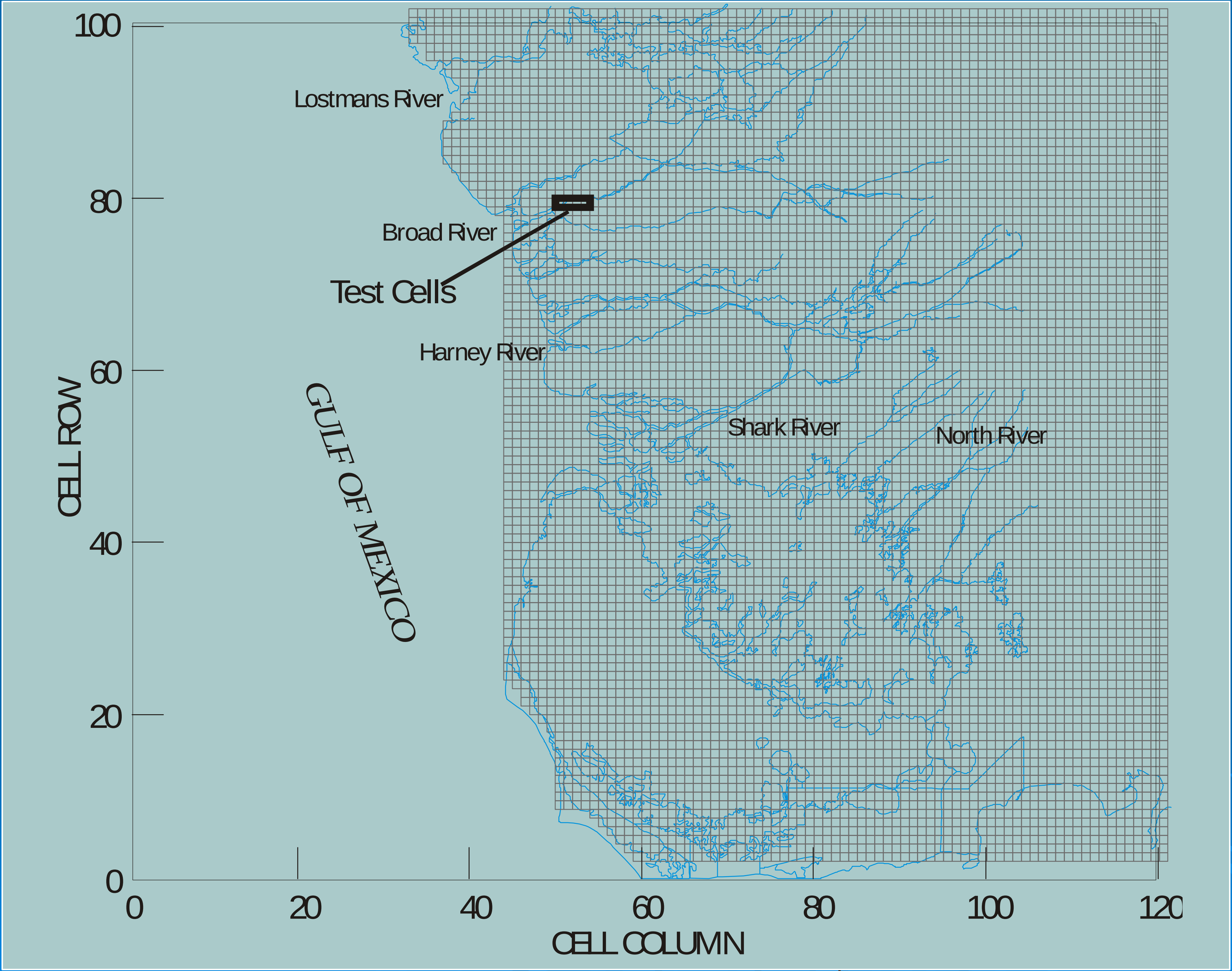

Location of four Hindcast model test cells

Results of PEST/hindcast test run

Cell 1 is originally submerged continuously.
Cells 2, 3, and 4 are dry

- Cell 1 – hydroperiod 360 days – raised 1.4 m
- Cell 2 – hydroperiod 10 days – lowered 0.09 m
- Cell 3 – hydroperiod 20 days – lowered 0.23 m
- Cell 4 – hydroperiod 40 days – lowered 0.37 m

PEST/Hindcast Linkage Use

- **Analysis of historic aerial photogrammetry provides estimates of coastal inundation change and salinity changes**
- **Locations, parameters, and changes are defined for the PEST estimation**
- **The Hindcast model is iteratively run by PEST while elevation is varied to best match criteria.**

- **Model results lend insight into possible coastal elevation changes over the 80 years between the Hindcast simulation and existing conditions.**

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USGS Modeling Team and Collaborating Scientists

- **USGS Fort Lauderdale**
  - Eric Swain
  - Melinda Lohmann
  - Jeremy Decker
  - Don DeAngelis
- **USGS Gainesville**
  - Brad Stith
  - Catherine Langtimm
- **USGS St. Petersburg**
  - Dennis Krohn
  - Tom Smith
- **USGS Tampa**
  - Joseph Hughes
- **Collaborating Scientists**
  - Jon Cline, University of Tennessee
  - 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.

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