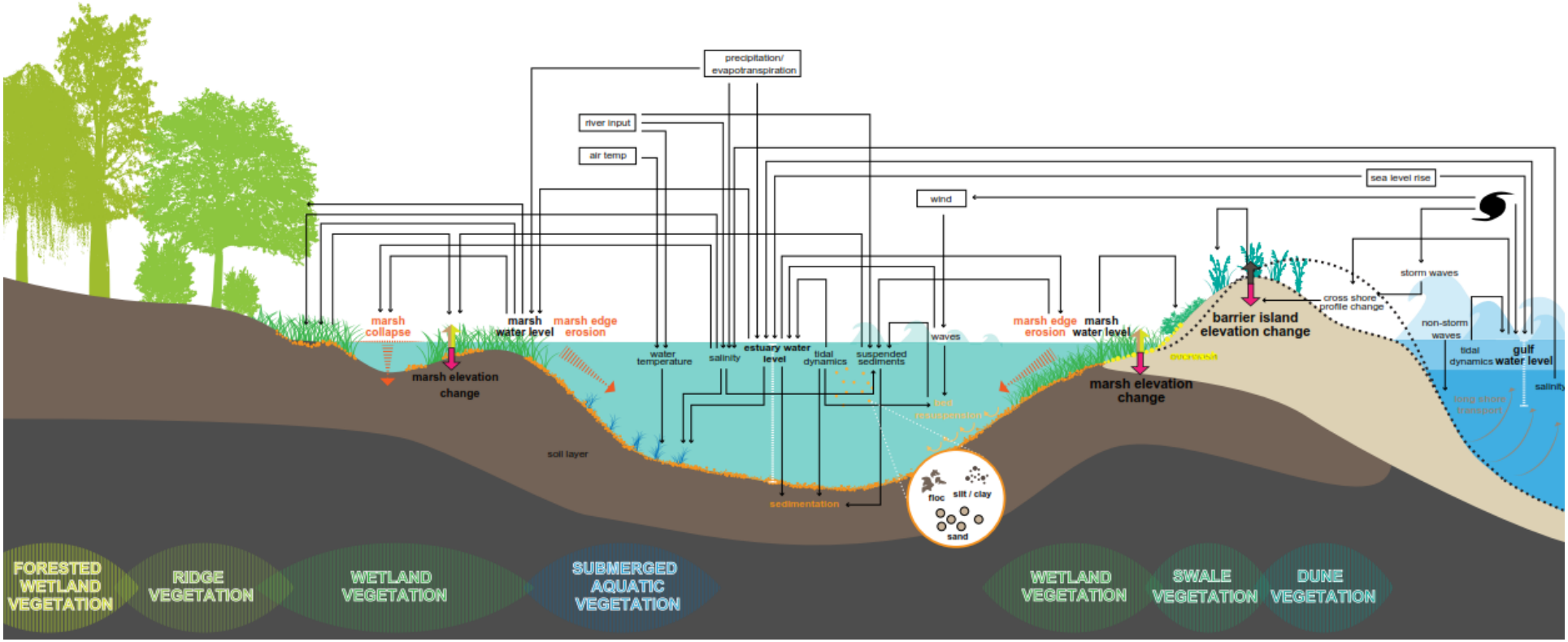


COASTAL ECOSYSTEM INTEGRATED COMPARTMENT MODEL (ICM)

Ehab Meselhe, Water Institute of the Gulf | May 2015

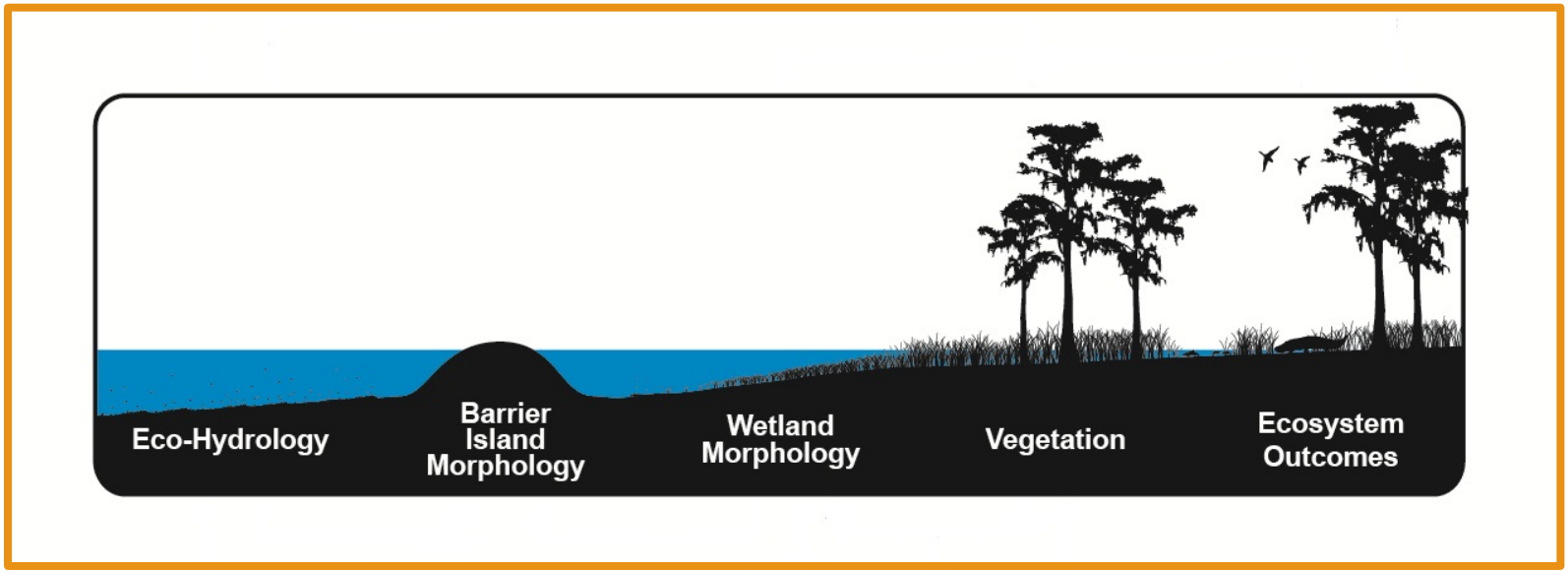
Outline

- Overall philosophy
- Processes represented in the ICM
- Model calibration and performance assessment
- Uncertainty analysis
- Closing Remarks

Overall Philosophy

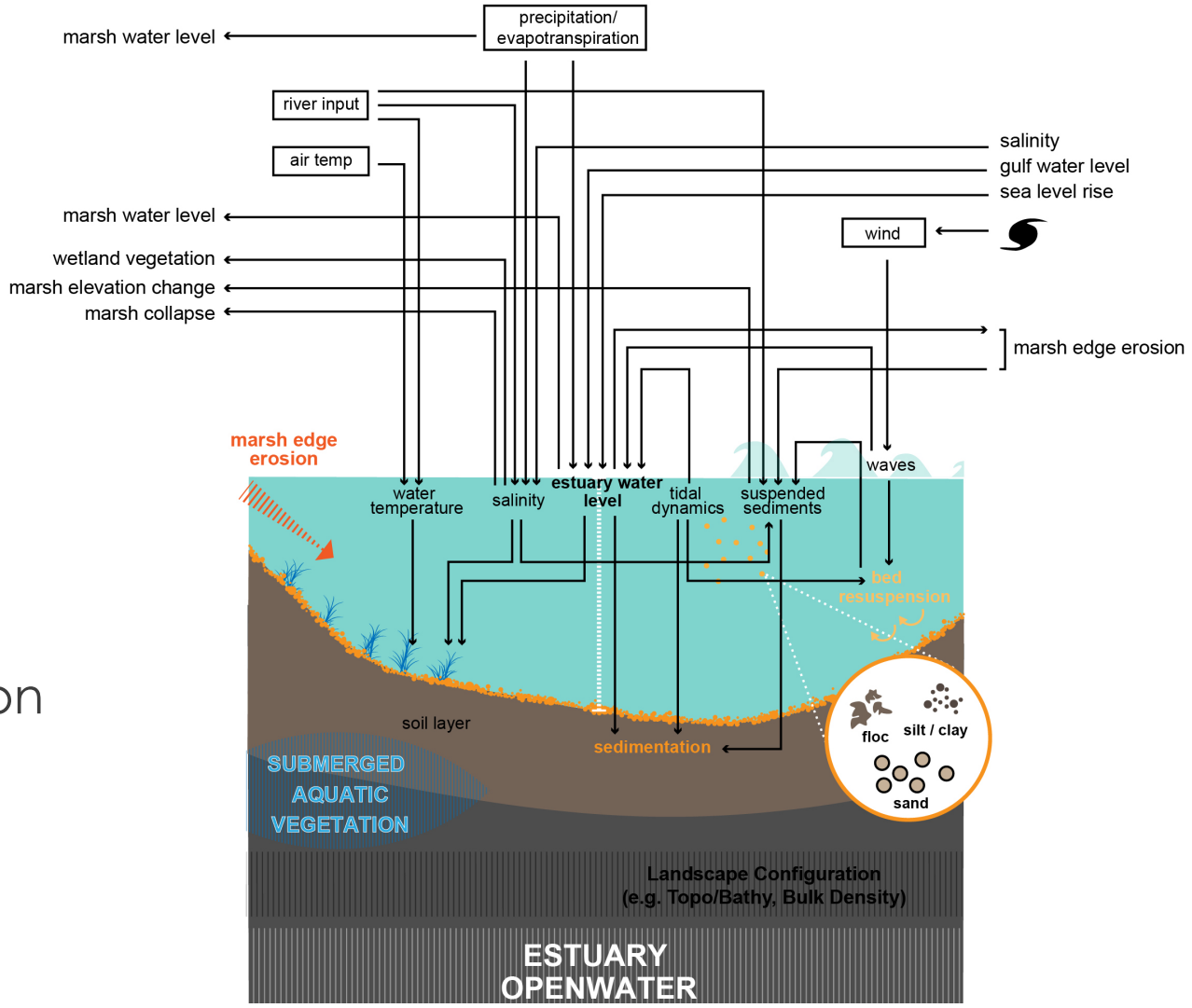
- Open Source
  - Coding language
  - Operating system
  - Reliance on proprietary software package
- Replicating reality versus capturing relevant processes
- Simplifying assumptions and computational efficiency
- Uncertainty analysis
- Future scenarios: climate change and environmental variability

Integrated Compartment Model (ICM)

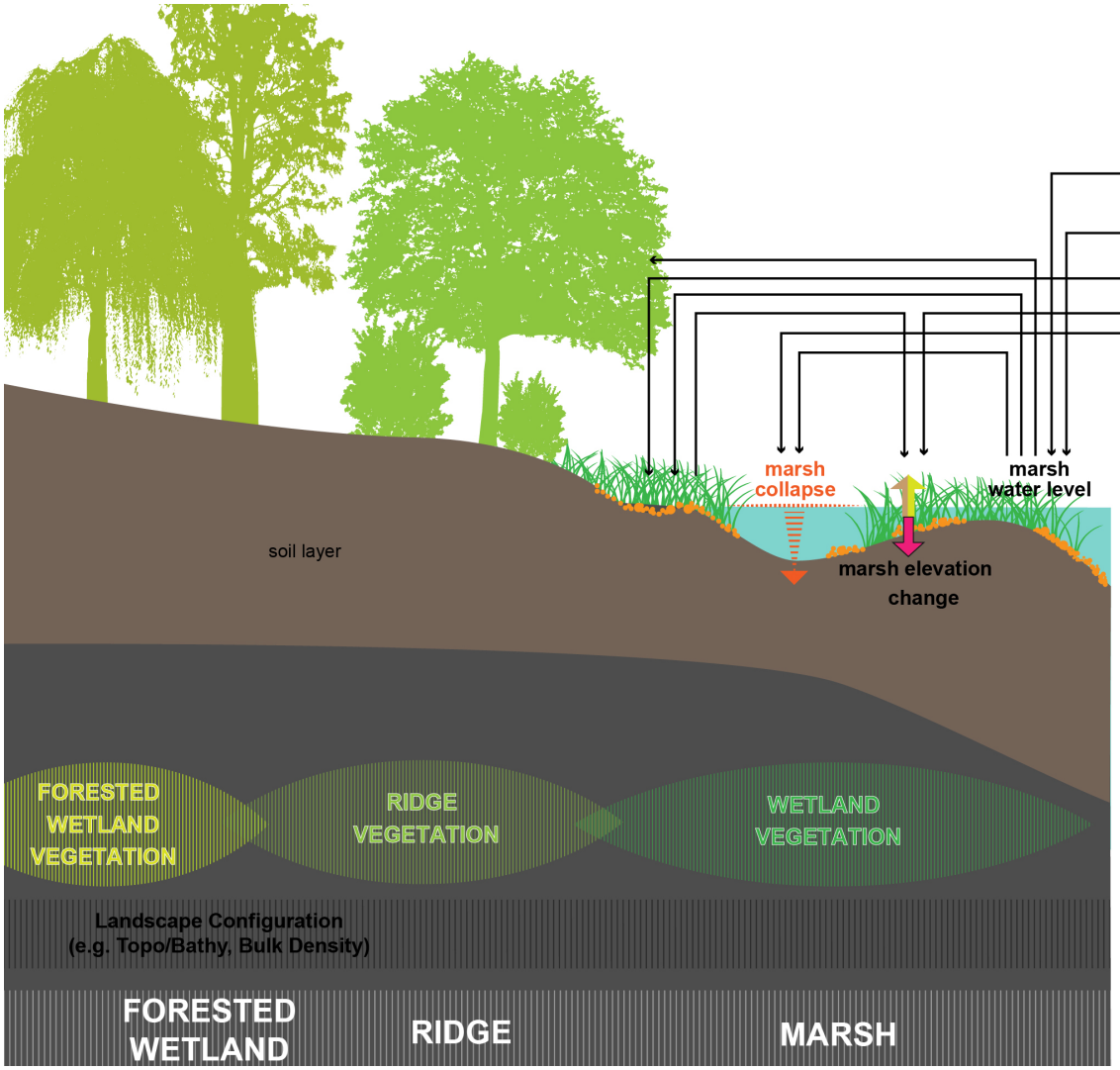


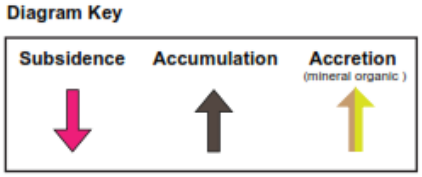
Estuary and Open Water Processes

- Hydrodynamics
- Water quality
- Sedimentation
- Bed resuspension
- Sediment distribution



Wetland Processes and Vegetation

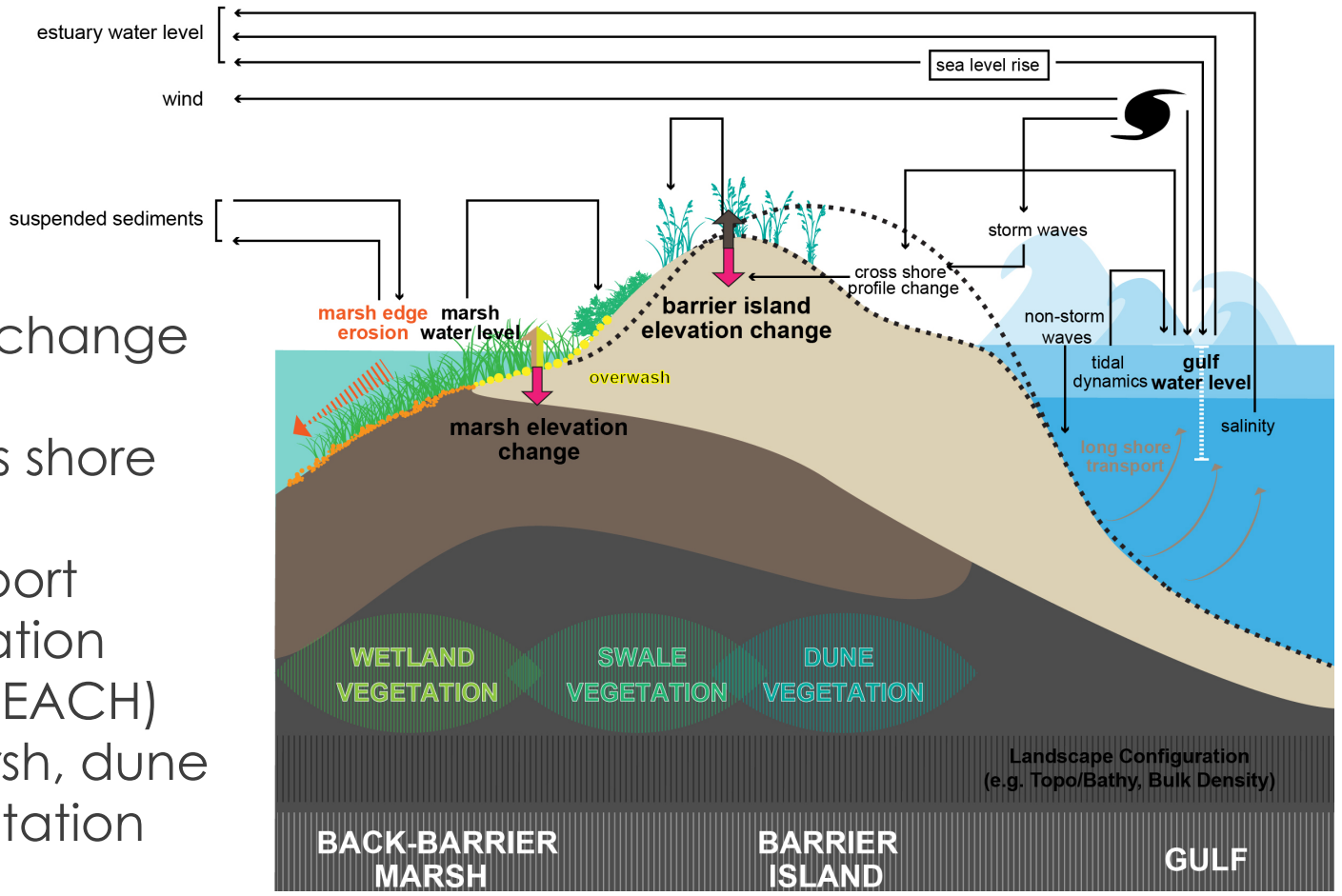




- Wetland elevation change
- Wetland area change
- Marsh collapse
- Marsh edge erosion
- Storm effects
- Coastal vegetation

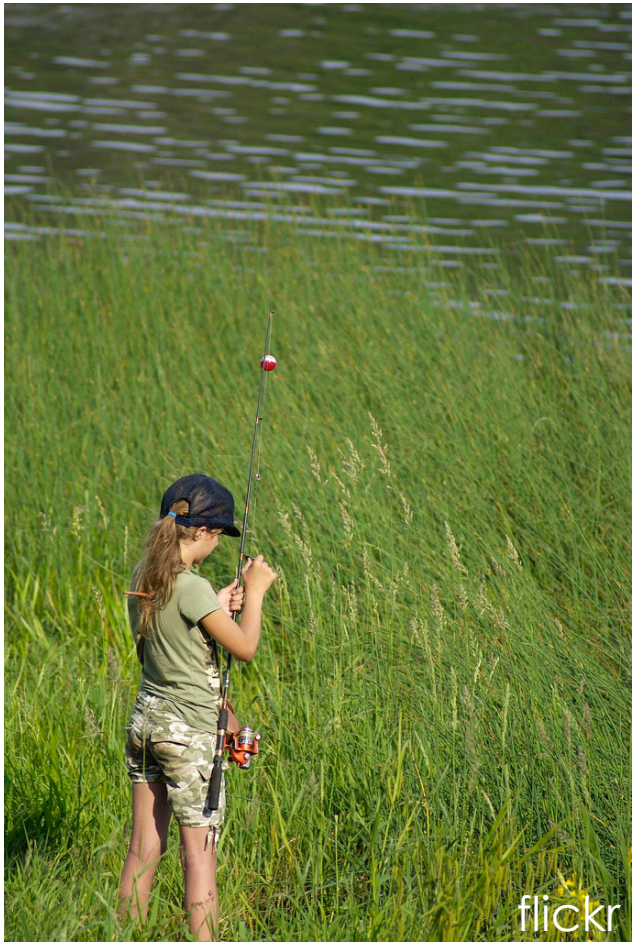
Barrier Island Processes

- Island elevation change
- Breaching
- Overwash / cross shore profile change
- Longshore transport
- Wave transformation
- Storm effects (SBEACH)
- Back-barrier marsh, dune and swale vegetation

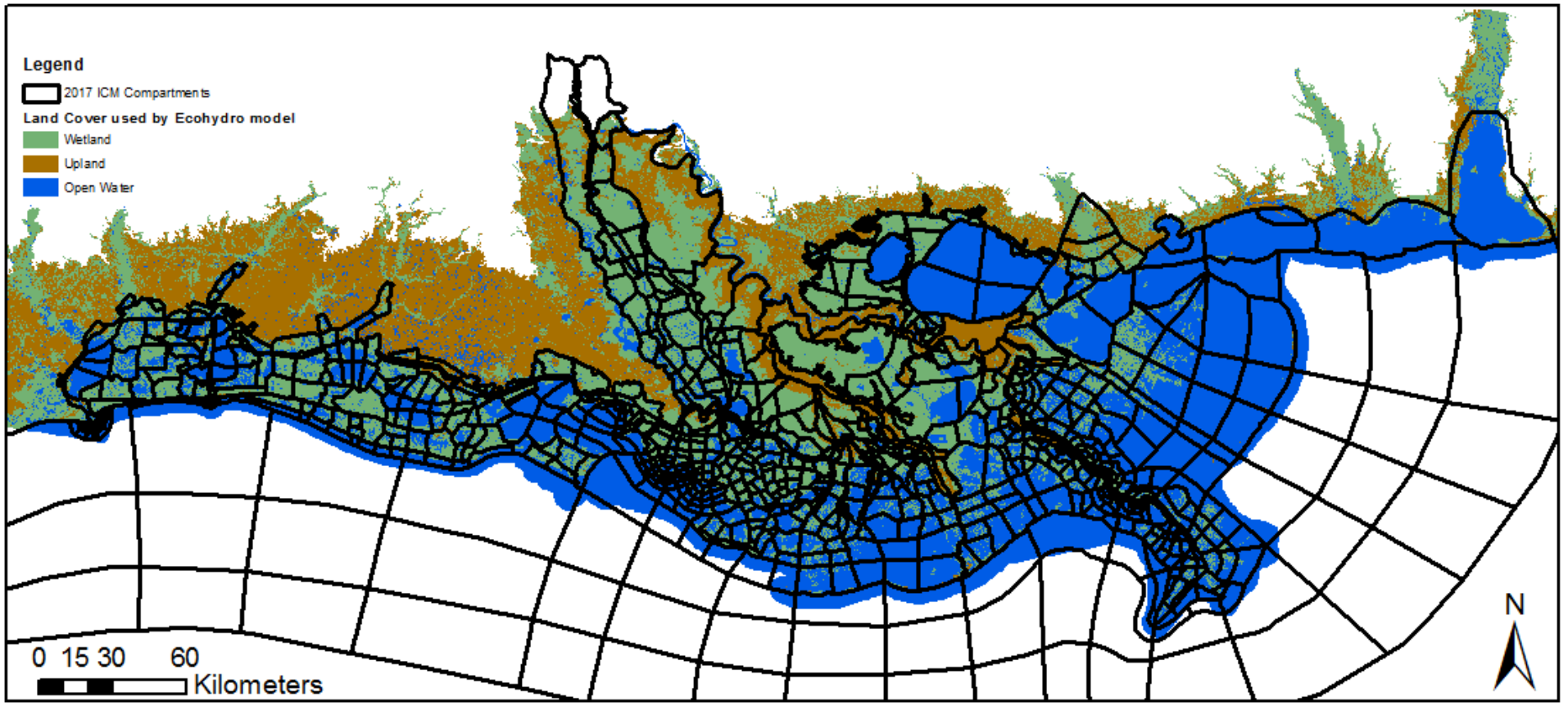


Ecosystem Outcomes

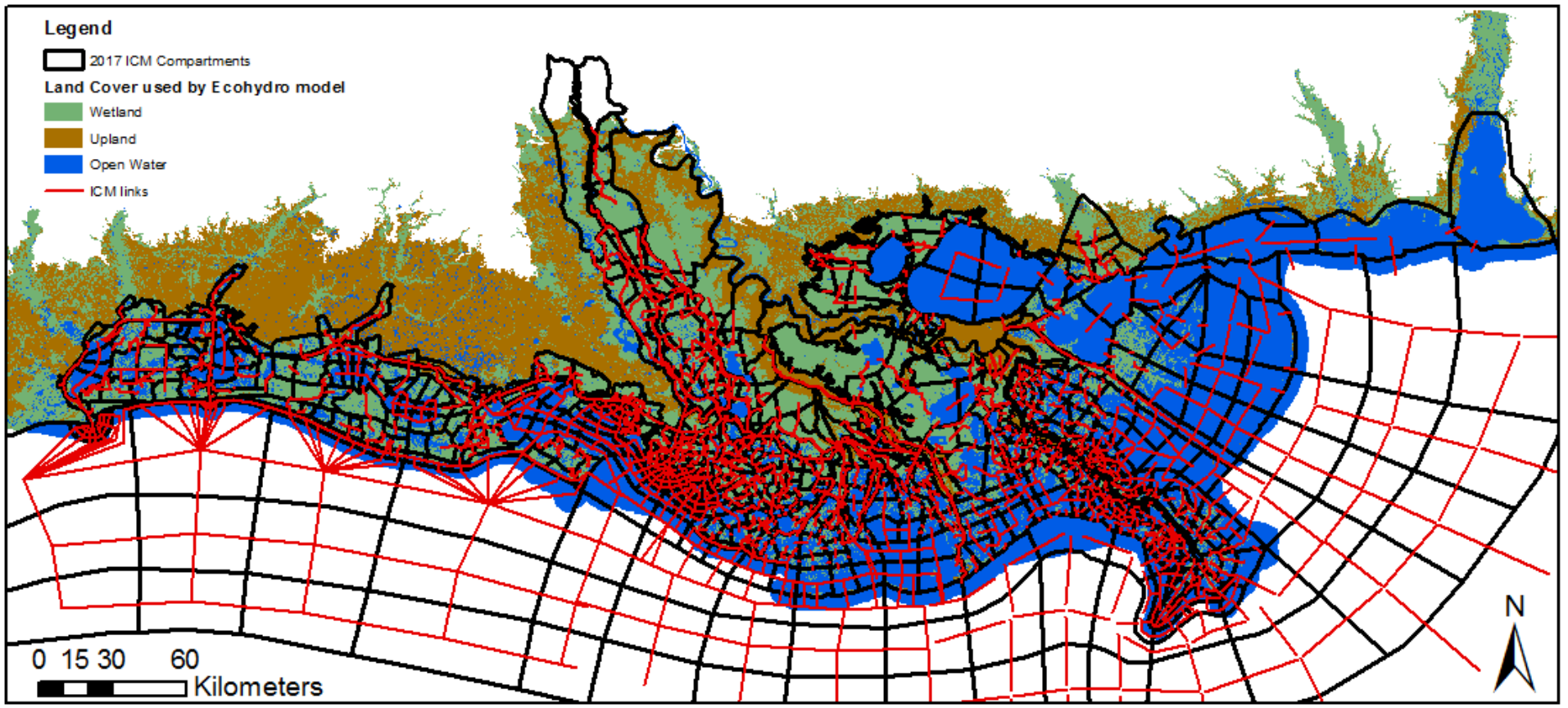
- Fish, shellfish, and wildlife HSIs
  - Statistical analysis
  - Coded into the ICM
- EwE (Ecopath with Ecosim)
  - Community fish and shellfish model
  - Dynamically coupled to the ICM
- Additional ecosystem outcomes
  - Nitrogen uptake
  - Storm surge attenuation
  - Agriculture
  - Carbon



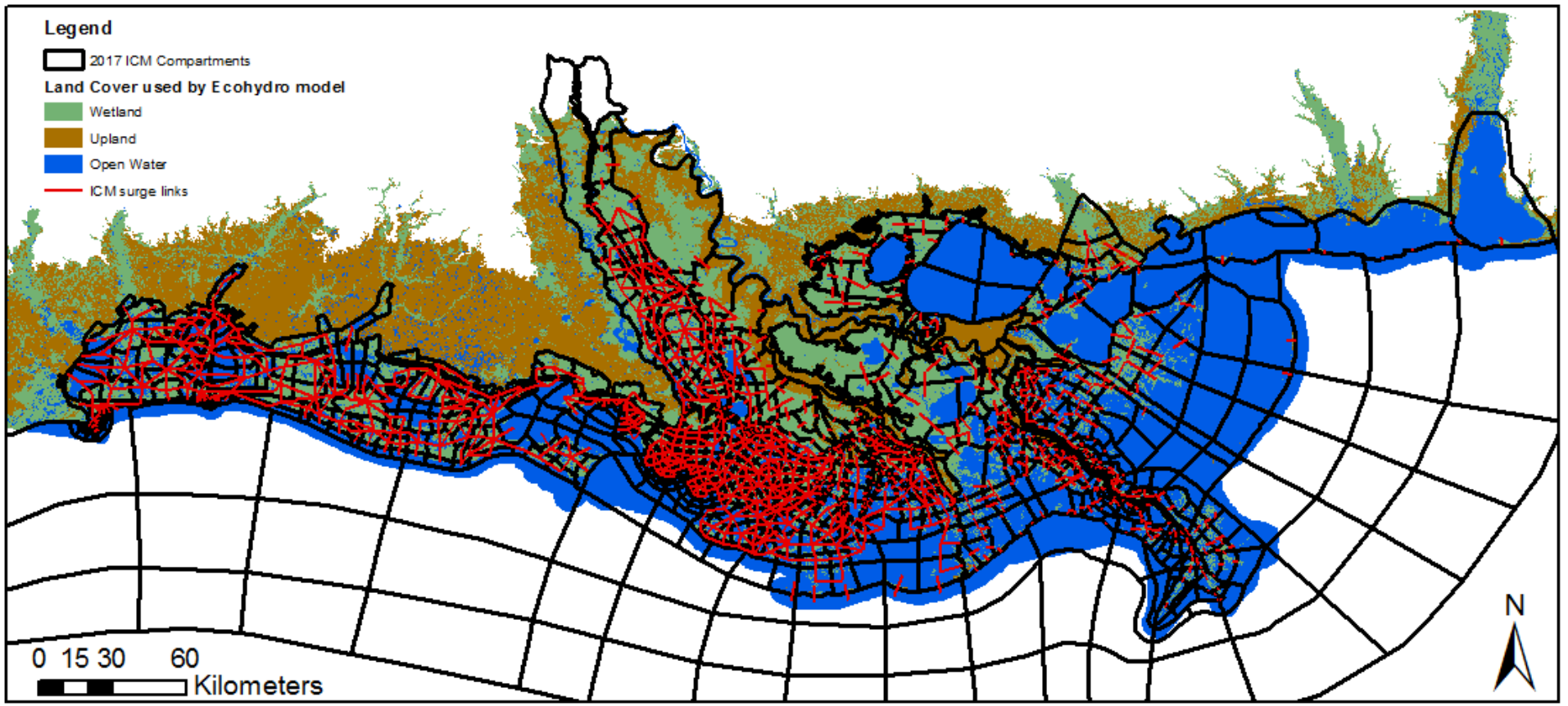
ICM Compartments



Hydraulic Link Network



Hydraulic Overland Flow (e.g. surge) Link Network



Alex McCorquodale, Jenni Schindler, Mallory Rodrigue,
Eric White, Robert Miller, Zhanxian 'Jonathan' Wang

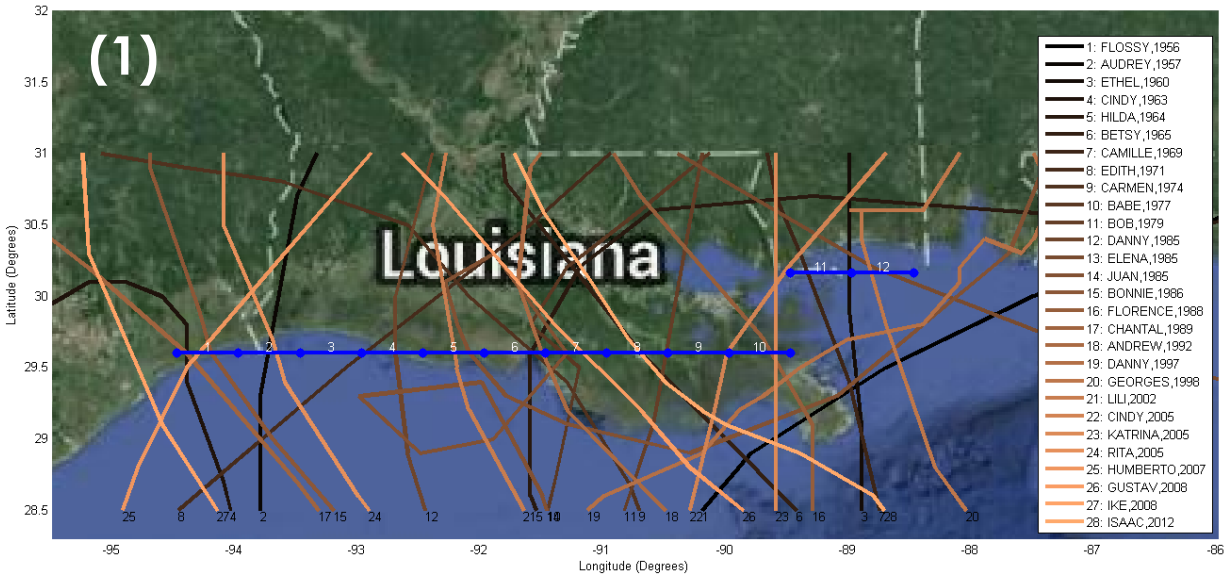
Storms in the Landscape

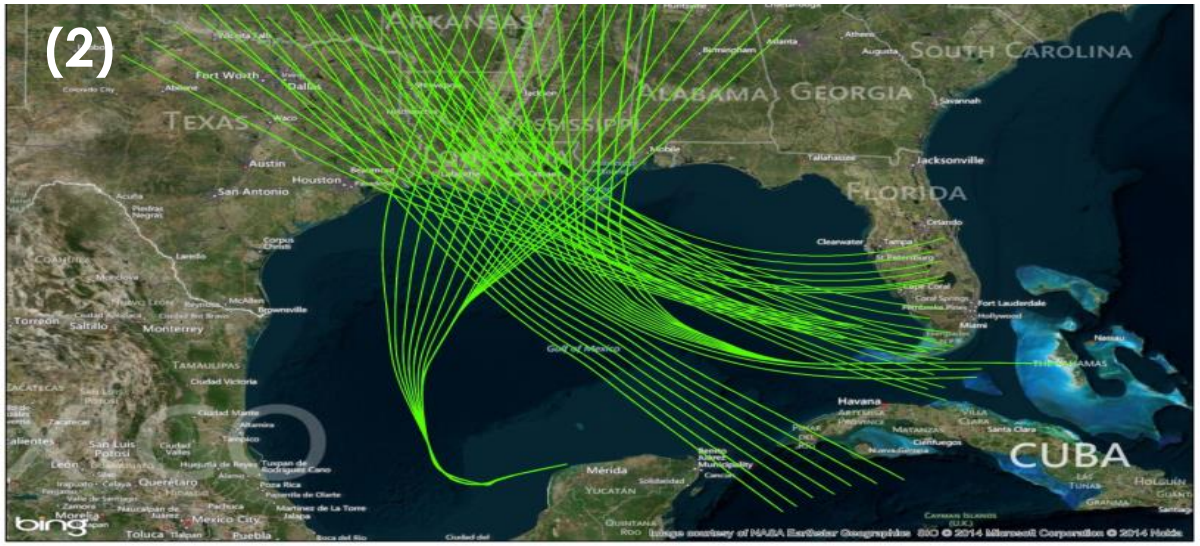
(1) Identify historical hurricane strikes (1950-2013)

(2) Locate 'matching' synthetic storms

(3) Apply storms as forcings in the 50-year ICM model runs

(4) Impacts to the landscape, including islands

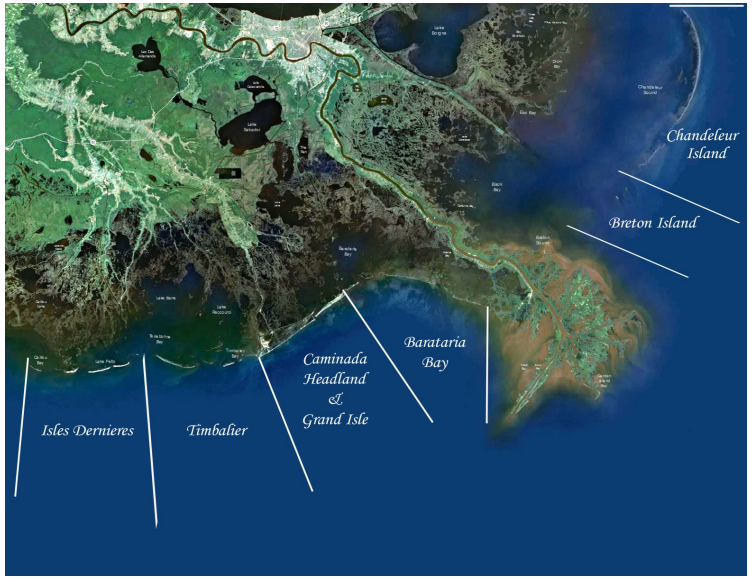




John Atkinson, Haihong Zhao, Hugh Roberts

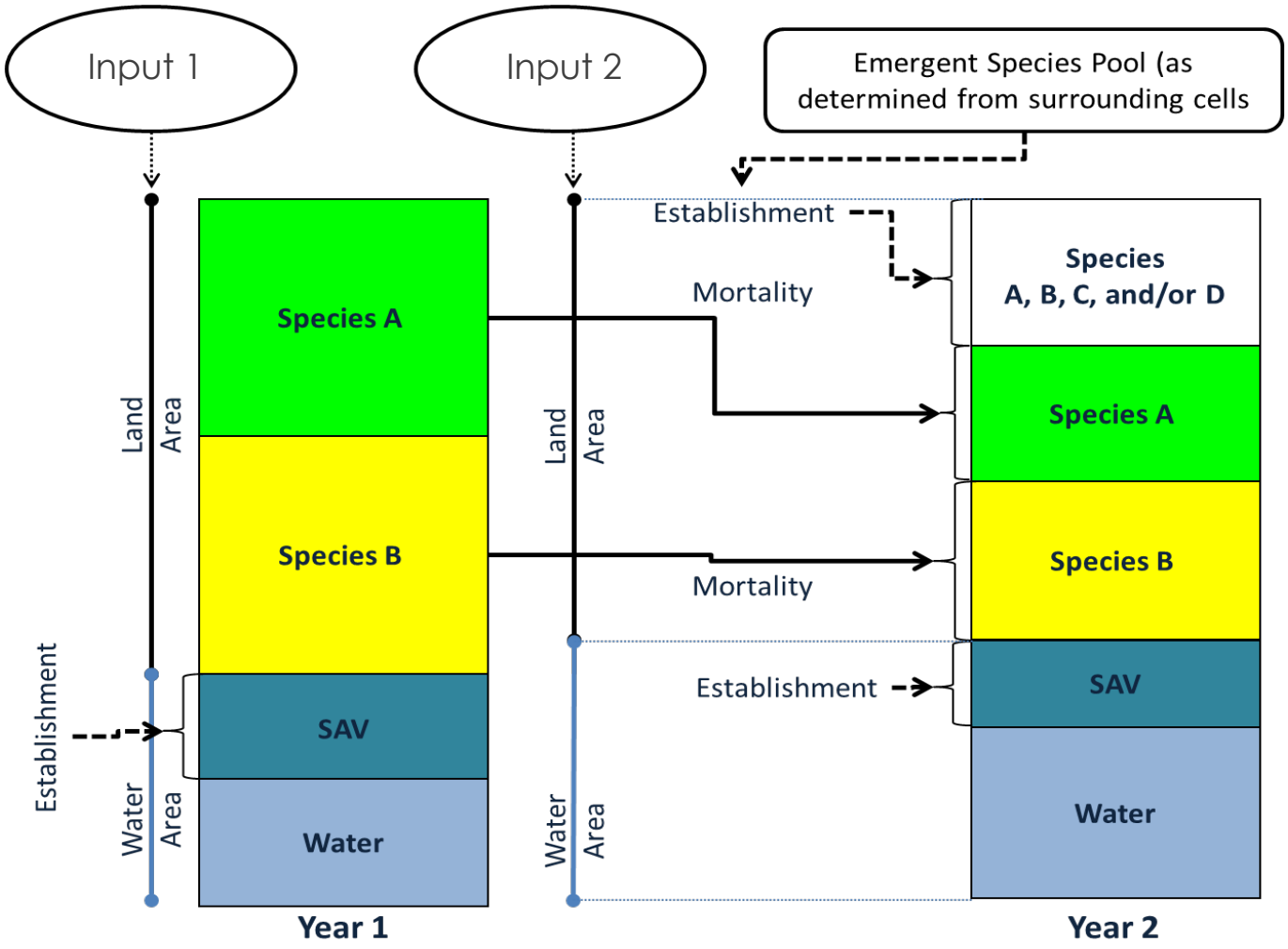
Barrier Islands

- Wave transformation (SWAN)
- Longshore sediment transport (2012 coding)
- Cross-shore sediment transport (SBEACH)
- Breaching - historical data (critical width & width/length ratios)
- Inlets & bays (2012 coding)
- Back-barrier marsh erosion
- Explicit tropical event effects on the landscape



Michael Poff, Gordon Thomson, Zhifei Dong, Dirk-Jan Walstra, Ioannis Georgiou, Mark Kulp, Mark Leadon, Darin Lee

Vegetation Conceptual Model



Habitat Suitability Indices

- Literature reviews and life cycle descriptions
- Subject-matter experts to develop/revise equations
- Statistical analysis of existing fishery independent data
- Coded directly into the ICM
- **Fish / shellfish**
  - Bay anchovy (NEW)
  - Blue crab (NEW)
  - Gulf menhaden (NEW)
  - Largemouth bass
  - Spotted seatrout
  - Brown shrimp
  - White shrimp
  - Eastern oyster

Wildlife

- Pelican (NEW)
- Alligator
- Crawfish
- Gadwall
- Green-winged teal
- Mottled duck

Fish & Shellfish: Ann Hijuelos, Shaye Sable, Meg O'Connell, Jay Geaghan (*statistical advisor)*
Wildlife: Hardin Waddle, Robert Romaire, Paul Leberg

Ecopath with Ecosim (EwE)

- Ecopath - virtual representation of the ecosystem
- Ecosim - temporal dynamic simulations
- Ecospace - spatial and temporal dynamic simulations (1 km^2 grid, monthly output, 20 and 50 year runs)
- Species of interest
  - Oysters (adult and spat), juvenile and adult life stages for brown shrimp, white shrimp, blue crab, Gulf menhaden, Gulf sturgeon, red drum, speckled trout, black drum, Atlantic croaker, sheepshead, striped mullet, bay anchovy, southern flounder, largemouth bass, sunfishes, and blue catfish
- Other important components of the foodweb
  - Phytoplankton, zooplankton, detritus, other forage species
- Environmental factors
  - Salinity, temperature, turbidity, marsh cover or edge, total nitrogen
- Fishing
- Dynamic base maps with habitat characteristics (Ecospace)

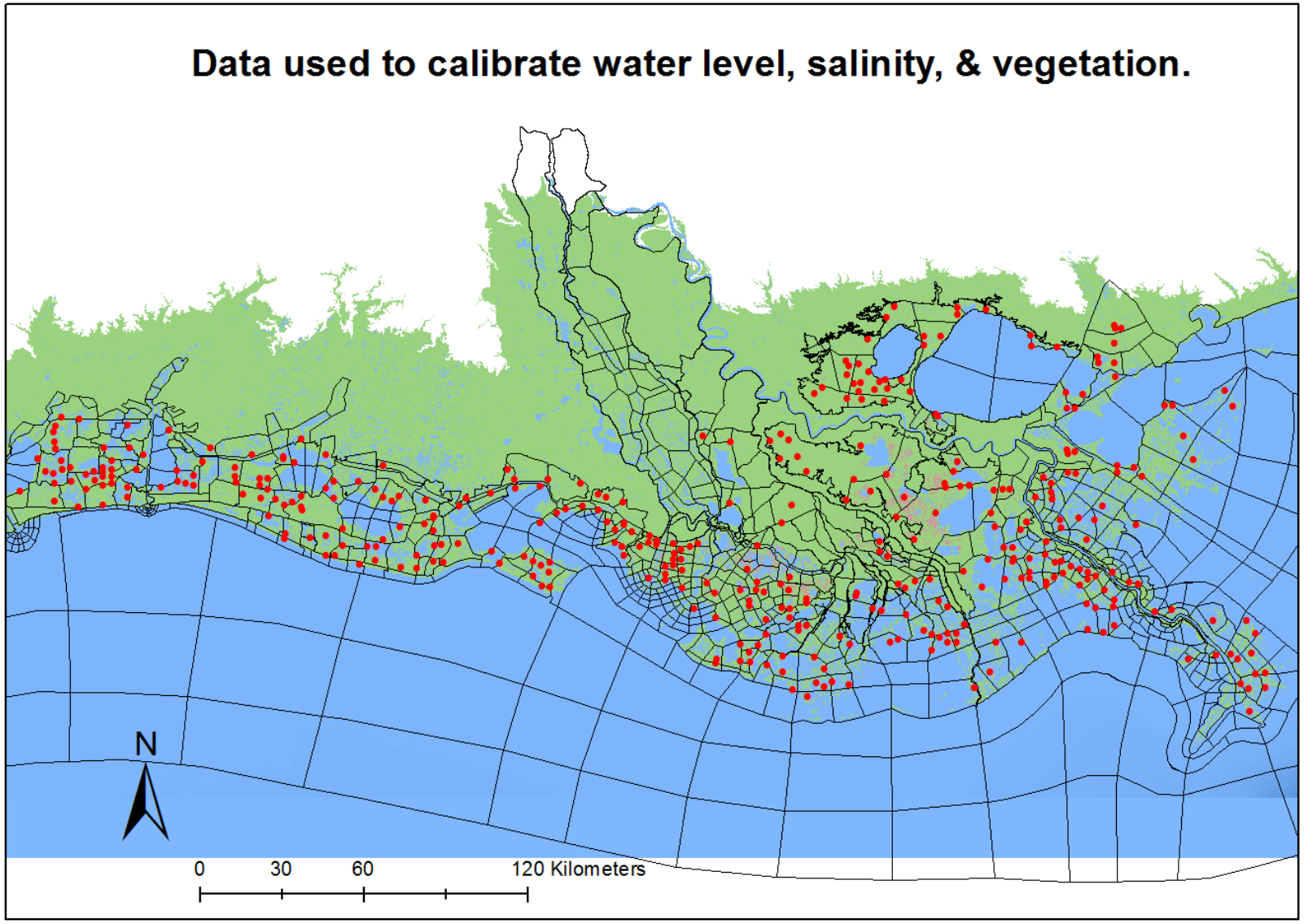
Model calibration: Preliminary results

Hydro team:
Stokka Brown & Zhanxian Wang – Moffatt & Nicholl
Jenni Schindler & Mallory Rodrigue – Fenstermaker
Alex McCorquodale – University of New Orleans
Eric White, Yushi Wang & Ehab Meselhe – The Water Institute of the Gulf

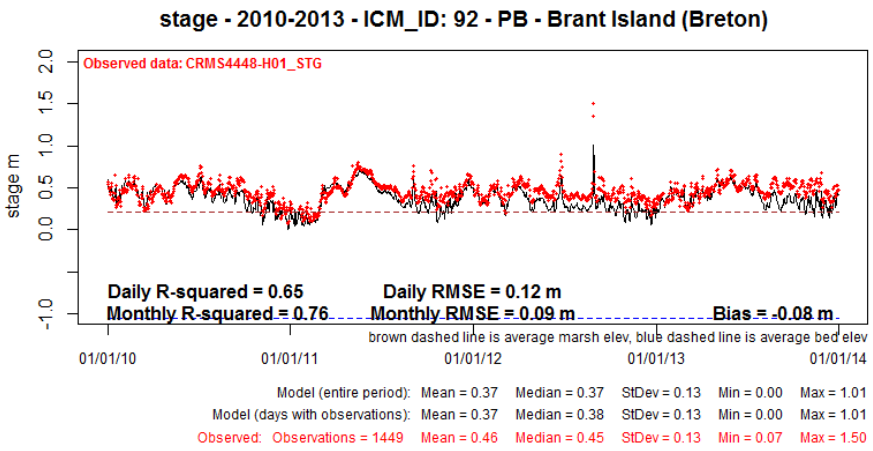
Veg team:
Jenneke Visser & Scott Duke-Sylvester – University of Louisiana at Lafayette

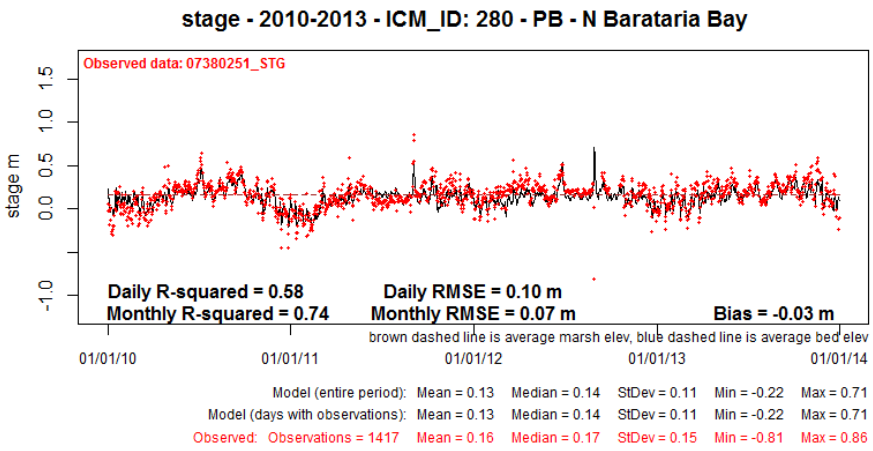
Barrier Island team:
Gordon Thomson & Zhifei Dong – CB&I

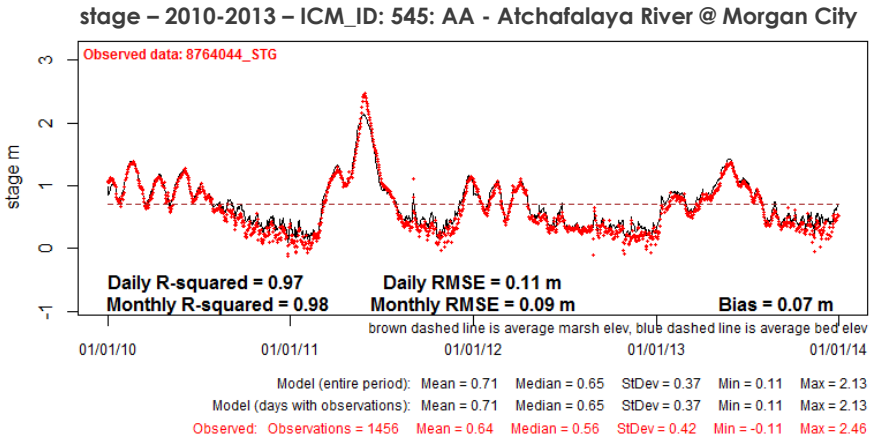
2017 Coastal Master Plan Integrated Compartment Model
Coastwide Reference Monitoring System (CRMS)

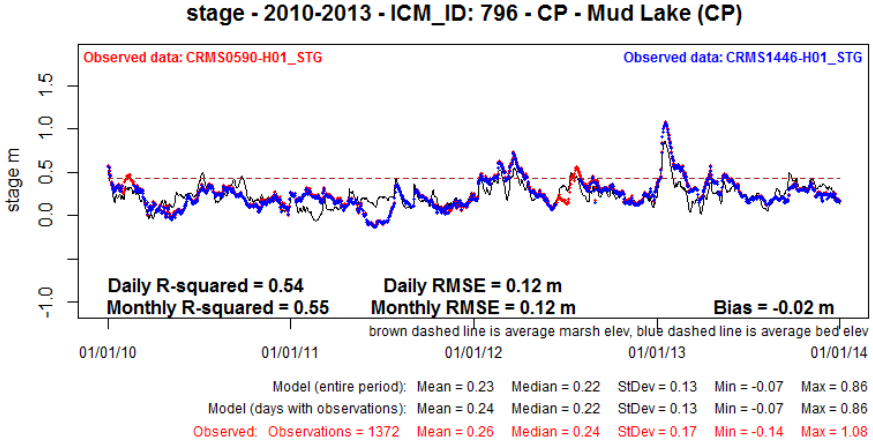


Stage Calibration – 201 sites



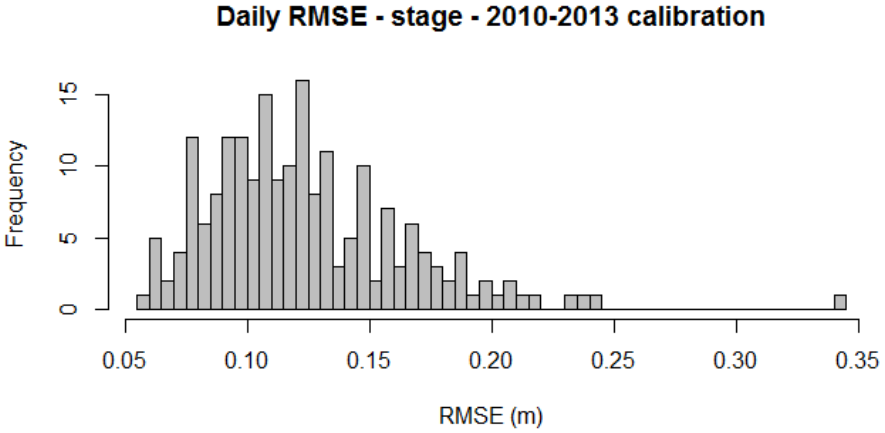


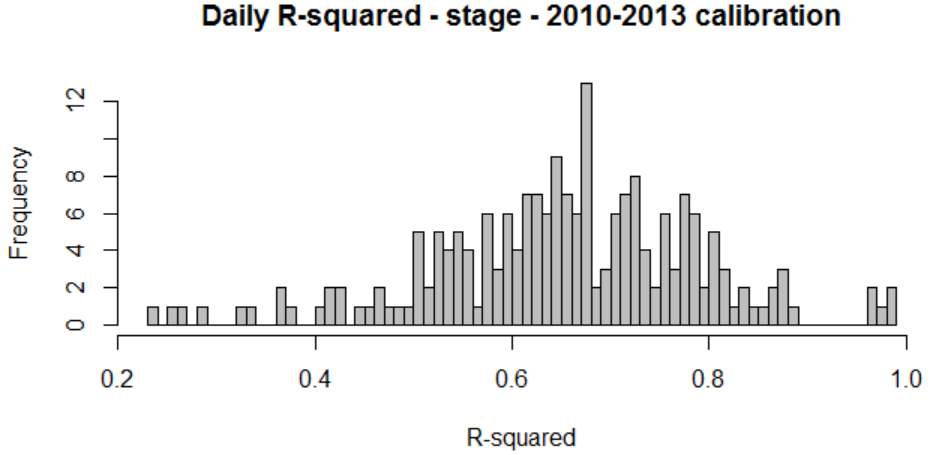


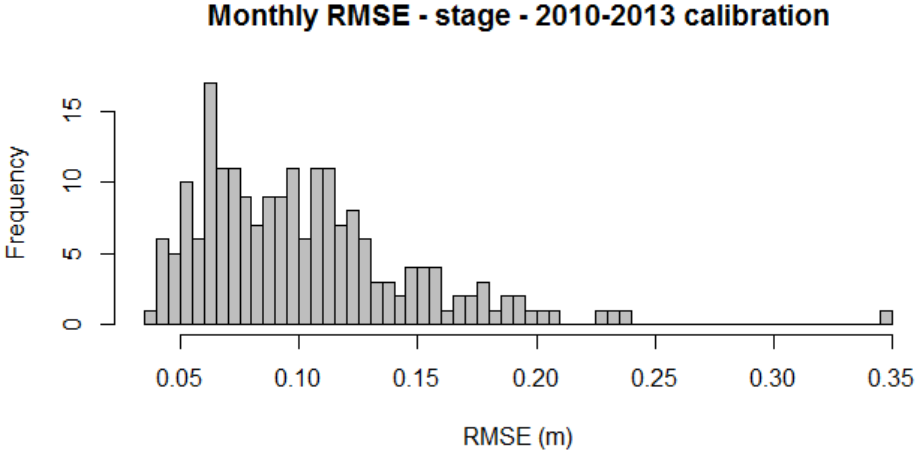


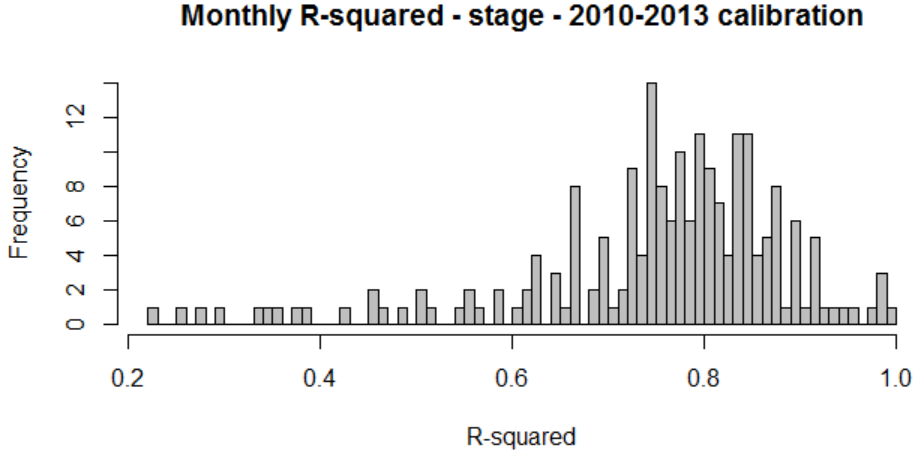
Stage Calibration – 201 sites

	Bias (m)	Monthly RMSE (m)	Monthly R^2	Daily RMSE (m)	Daily R^2
mean	0.00	0.10	0.75	0.12	0.65
stdev	0.08	0.05	0.14	0.04	0.14
min	-0.31	0.04	0.23	0.06	0.24
max	0.22	0.35	0.99	0.34	0.99

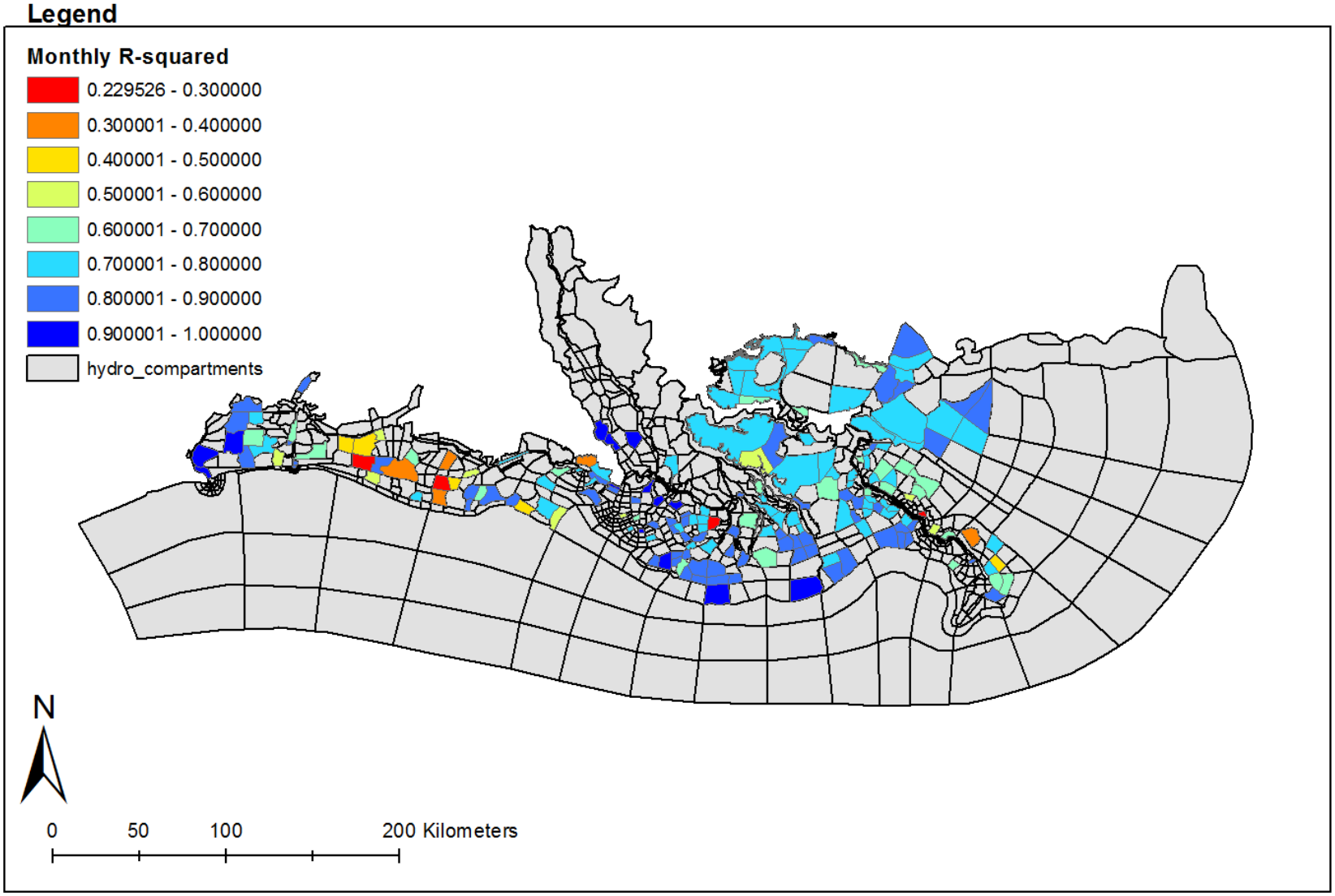




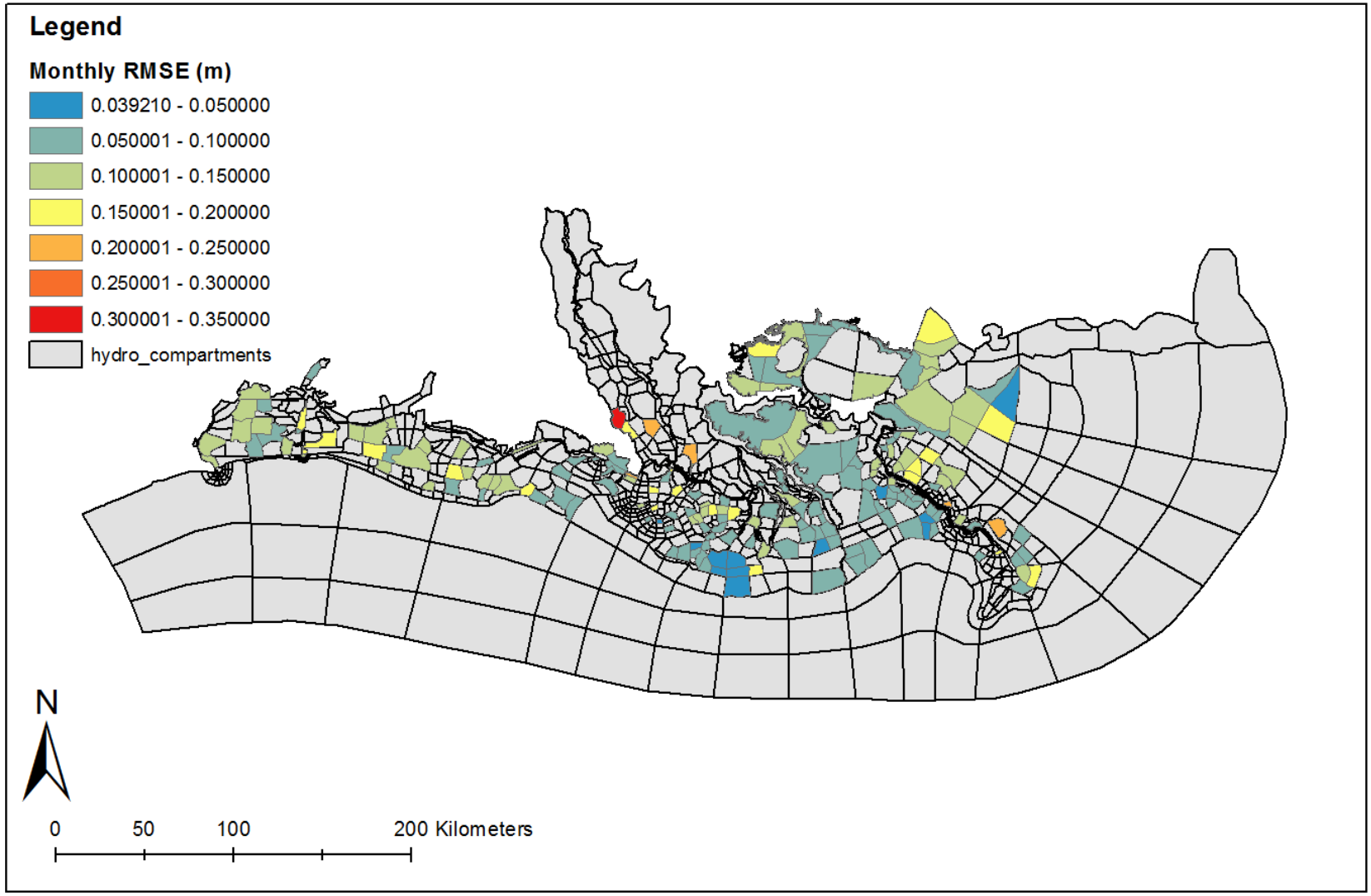




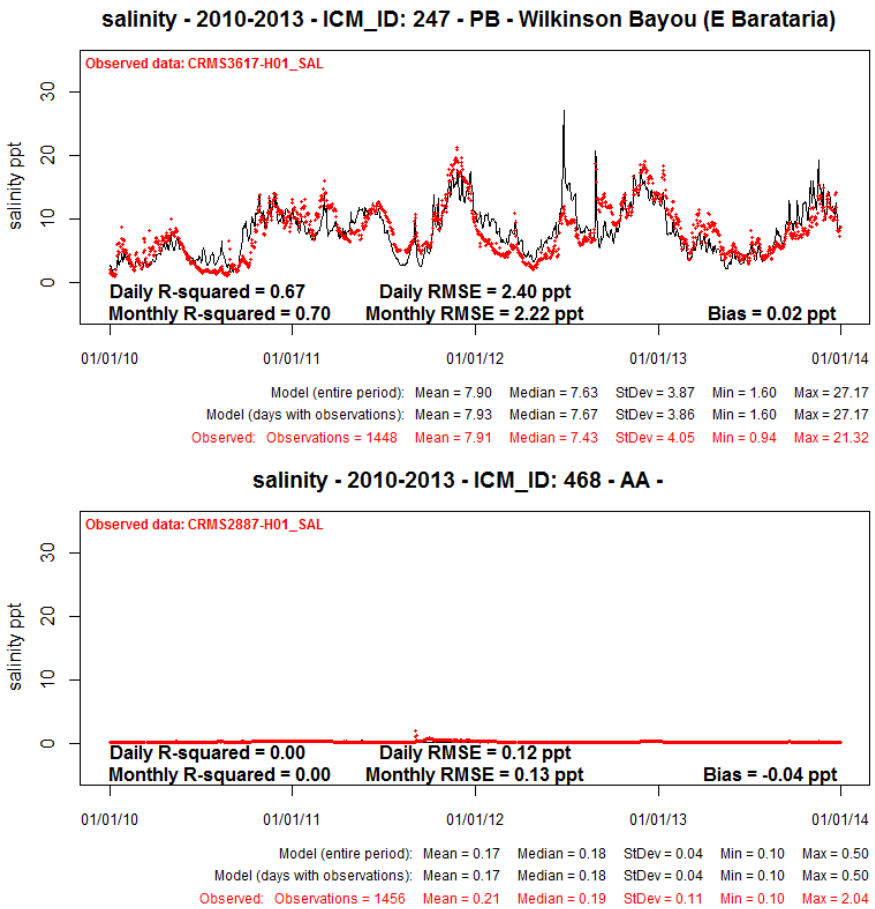
2017 Coastal Master Plan Integrated Compartment Model
Stage Calibration - Monthly R-squred

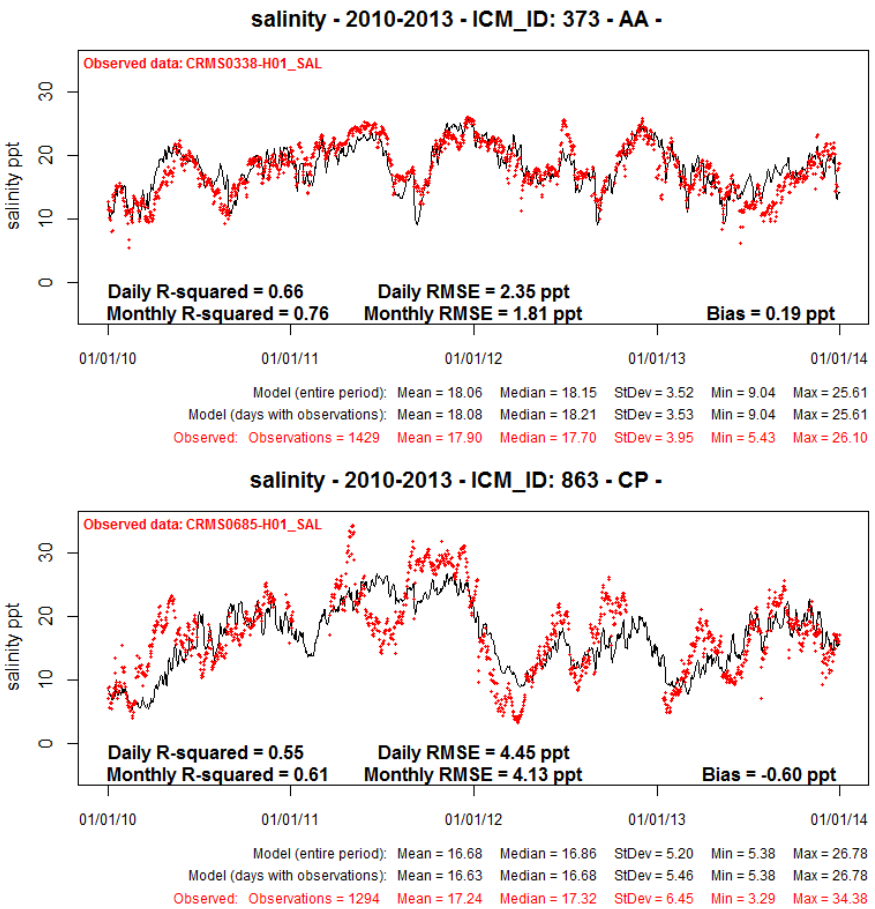


2017 Coastal Master Plan Integrated Compartment Model
Stage Calibration - Monthly RMSE (m)



Salinity Calibration





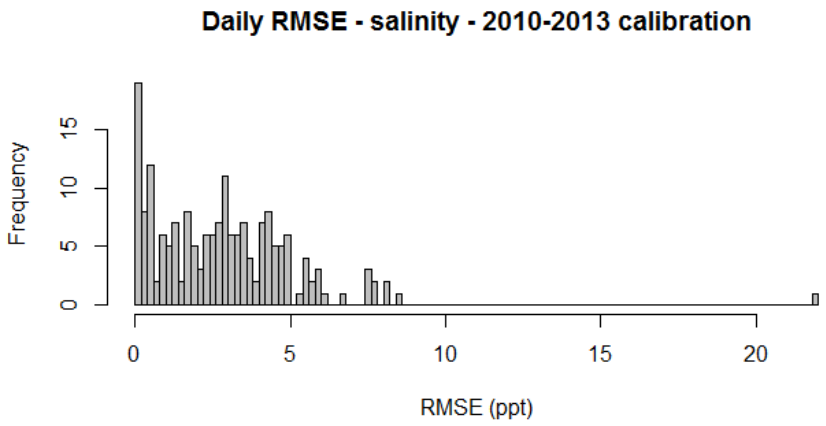
Salinity Calibration – 184 sites

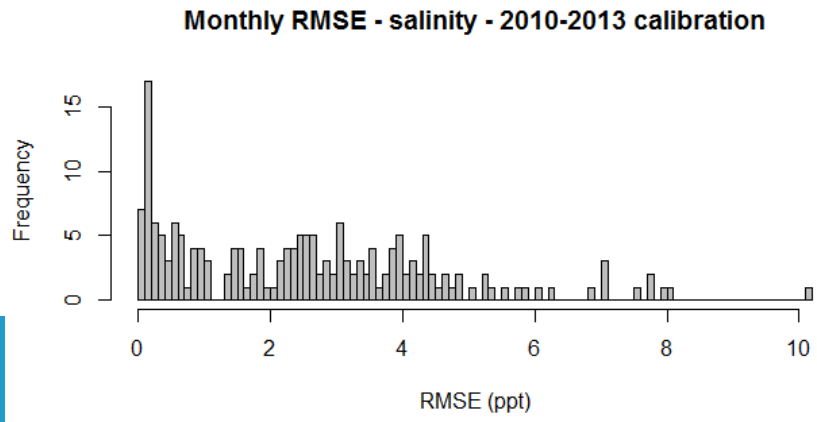
106 sites with observed mean < 5ppt

	Bias (ppt)	Monthly RMSE (ppt)	Monthly R^2	Daily RMSE (ppt)	Daily R^2
mean	0.2	1.3	0.3	1.5	0.3
stdev	0.9	1.3	0.3	1.3	0.2
min	-1.8	0.1	0.0	0.1	0.0
max	5.3	5.7	0.9	6.0	0.8

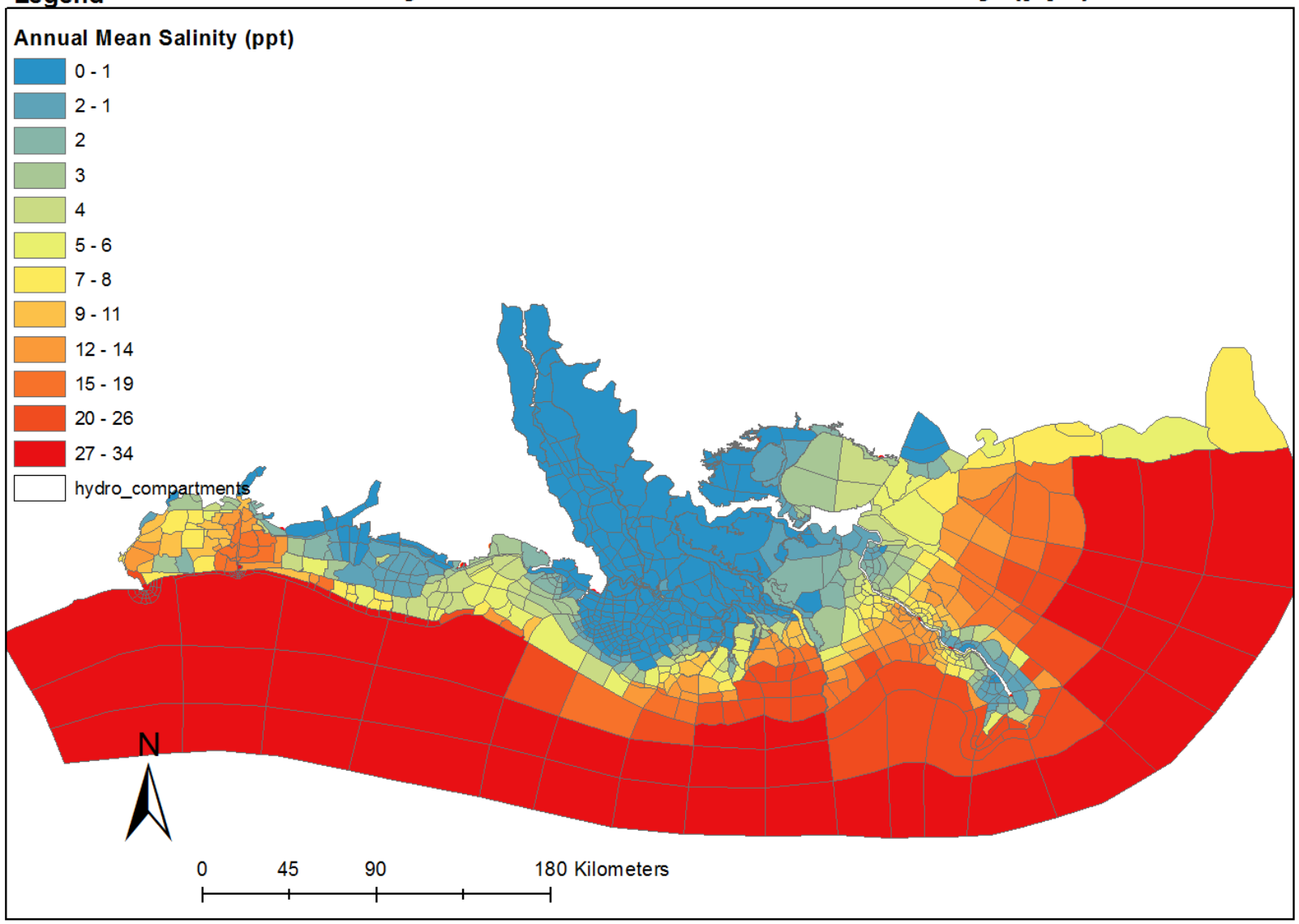
74 sites with observed mean 5 – 20 ppt

	Bias (ppt)	Monthly RMSE (ppt)	Monthly R^2	Daily RMSE (ppt)	Daily R^2
mean	-0.3	4.1	0.6	4.5	0.5
stdev	2.4	1.6	0.2	2.5	0.2
min	-7.0	1.8	0.0	2.3	0.0
max	5.7	10.1	0.9	21.9	0.9

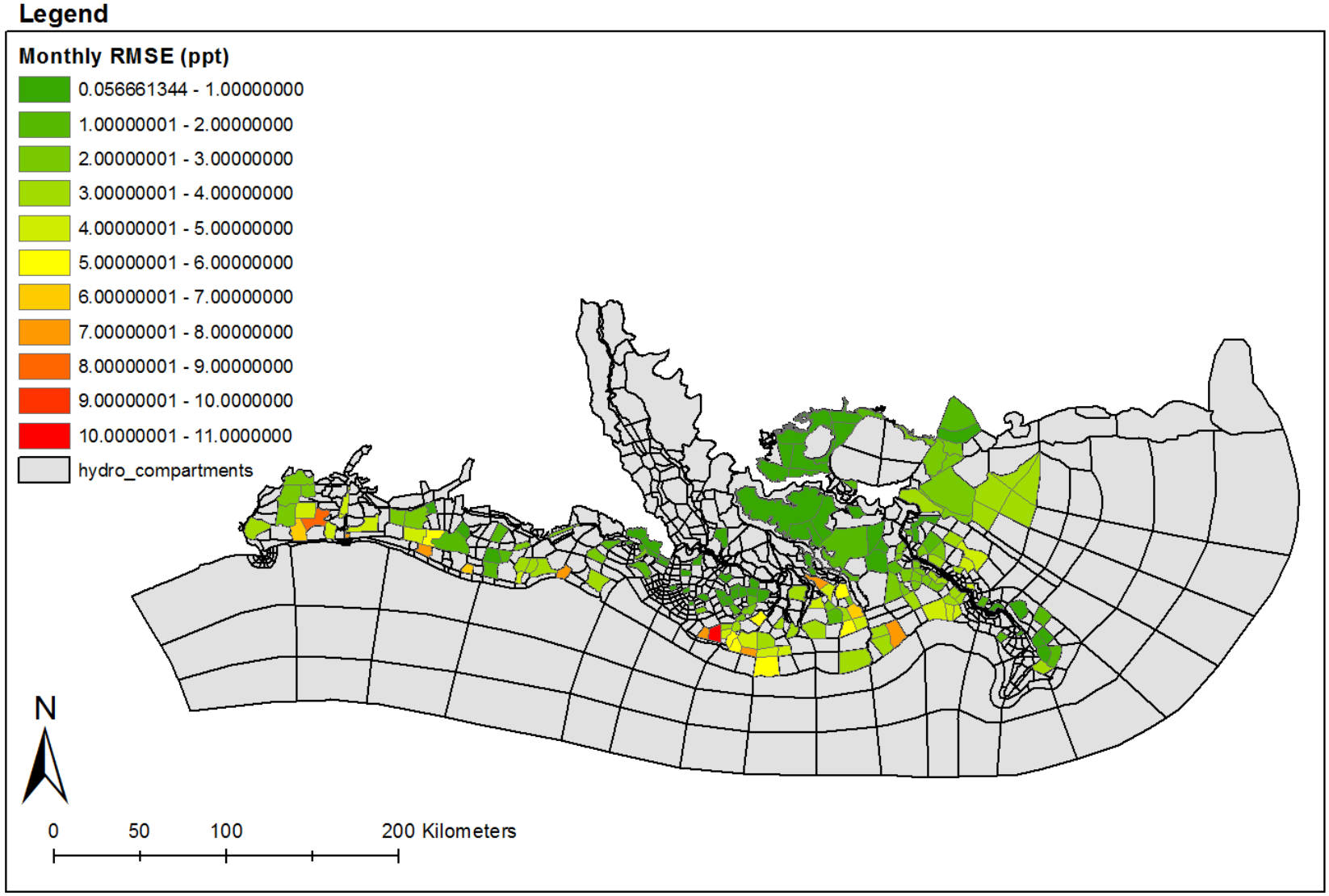




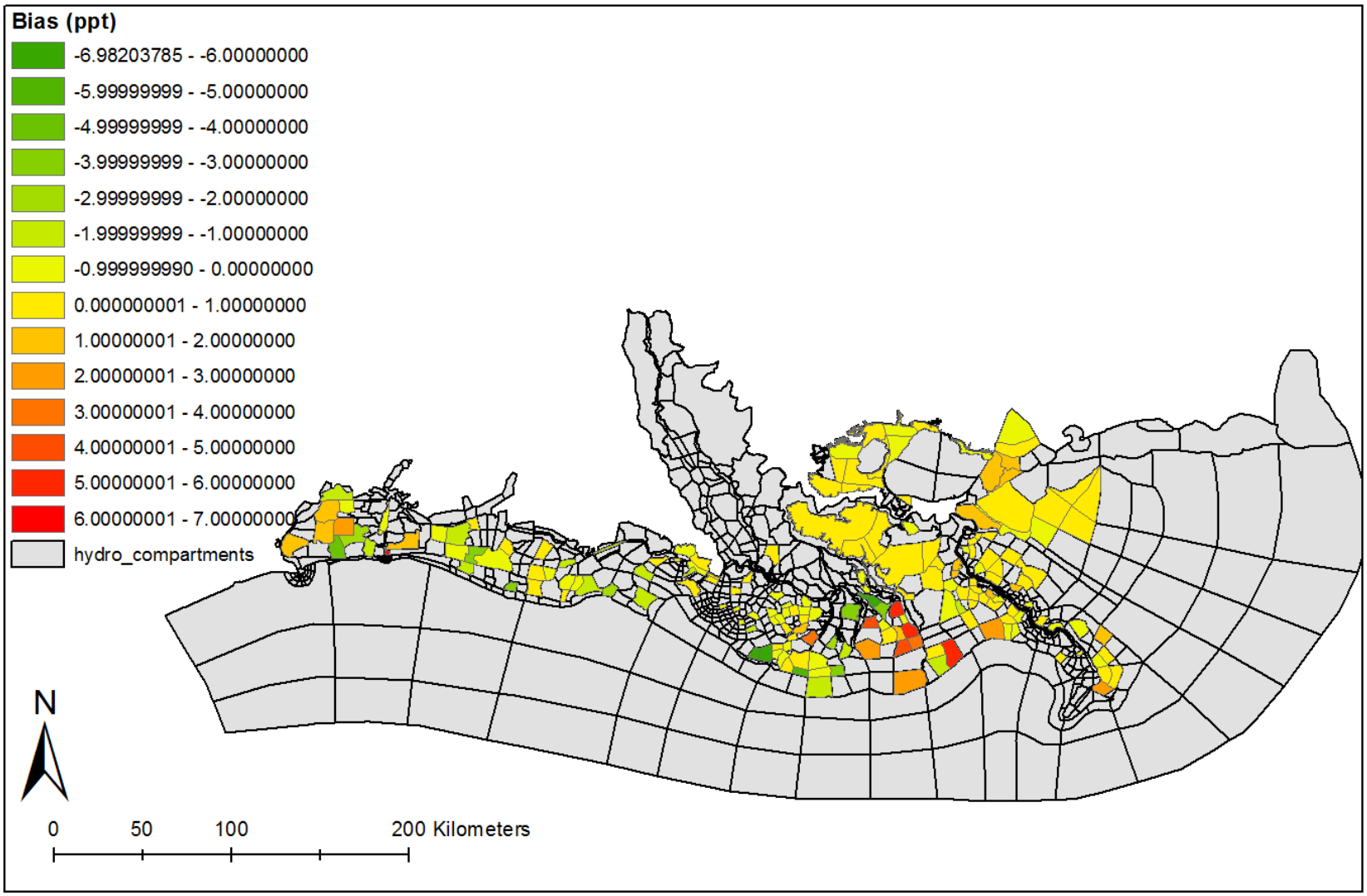
2017 Coastal Master Plan Integrated Compartment Model
Salinity Calibration - 2013 Mean Salinity (ppt)



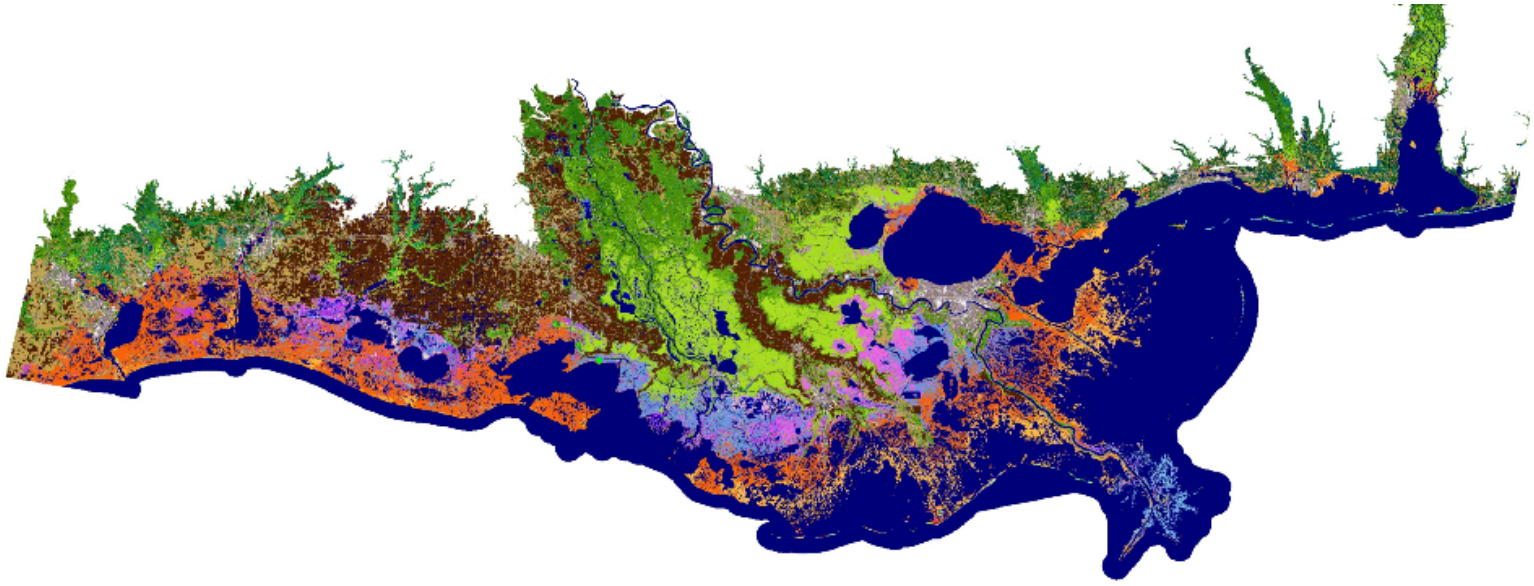
2017 Coastal Master Plan Integrated Compartment Model
Salinity Calibration - Monthly RMSE (ppt)



2017 Coastal Master Plan Integrated Compartment Model
Salinity Calibration - Bias (ppt)



2010 Vegetation Initial Condition Map



50 0 50 100 150 200 km

Legend

LAVegMod Initial Conditions

- QUTE
- QUVI
- QULA3
- ULAM
- QUVI
- QULE
- QUNI
- NYAQ2
- NYAQ2
- TADI2
- SANI
- NYAQ2
- TADI2
- CLMA10
- ELBA2
- ELBA2_Flt
- HYUM
- HYUM_Flt
- MOCE2
- PAHE2
- PAHE2_Flt
- SALA2
- TYDO
- ZIMI
- PHAU7
- SALA
- SCCA11
- BAHA
- IVFR
- PAVA
- AVGE
- SPPA
- DISP
- JURO
- SPAL
- STHE9
- SOSE
- DISPBI
- SPPABI
- SPVI3
- PAAM2
- UNPA
- BAHABI
- SAV
- NOTMOD
- BAREGRND
- BAREGRND
- Water

Vegetation Calibration Overview

Swamp		Fresh Marsh		Intermediate Marsh		Brackish Marsh		Saline Marsh	
Species	Fit	Species	Fit	Species	Fit	Species	Fit	Species	Fit
TADI2	**70**	TYDO	**78**	SALA	86	SPPA	**71**	SPAL	81
NYAQ2	90	PAHE2	96	PHAU7	87	JURO	88	DISP	**74**
SANI	91	HYUM	98	IVFR	90	PAVA	87	AVGE	100
		SALA2	98	BAHA	89				
		ZIMI	97	SCCA11	96				
		CLMA10	97						
		MOCE2	99						
Average	81		90		87		**75**		**77**

- Fit is the percentage of correctly classified stations in 2014 (both presence and absence)
- Average is the weighted average using species % of stations observed in 2012

BIMODE - Longshore Calibration Results

Location	Reported Transport (m^3/yr)	Modeled Sediment Transport Potential (m^3/yr)
Raccoon Island	40,000	18,000 to 31,000
Whiskey Island	40,000	37,000 to 39,000
Trinity & East Island	46,000	24,100 to 37,000
Timbalier Island	35,000	24,000 to 37,000
East Timbalier Island	41,000	600 to 5,000
West Belle Pass Barrier Headland	20,000	2,000 to 15,000
Caminada Headland	63,000	1,700 to 80,000
Grand Isle	63,000	2,000 to 48,000
West Grand Terre	30,000	4,300 to 21,000
East Grand Terre	40,000	21,000 to 39,000
Grand Pierre	-	44,000 to 53000
Chenier Ronquille	39,000	35,000 - 46,000
Chaland Headland	58,900	22,000 to 46,000
Bay Joe Wise	29,000	22,000 to 44,000
Shell Island West	40,000	44,000 to 53,000
Shell Island East	40,000	18,000 to 50,000
Pelican Island	20,000	15,000 to 31,000
Scofield Island	-	20,000 to 32,000
Breton Island	310,000	-
Chandeleur Island	800,000 to 1,100,000	500,000 to 900,000

Uncertainty Analysis

- Limited to parametric uncertainty
  - Key model parameters influencing model output
- Apply perturbations to output of modules prior to usage in subsequent modules
- Perturbations are guided by model performance during calibration & validation
- Observe influence of perturbation on key model outcomes, e.g.:
  - Land building
  - Critical species
  - Etc.

Future Scenarios

- Analyze influence of environmental parameters on model output
- Sea level rise
- Subsidence
- Rainfall
- Evapotranspiration
- Riverine inflow
- Sediment load
- Storm frequency and intensity

Closing Remarks

- Model calibration & validation is nearly complete
- Development of future scenarios is underway
- Uncertainty analysis is underway
- Model application to restoration and protection projects this summer
- Model distribution is expected in 2016

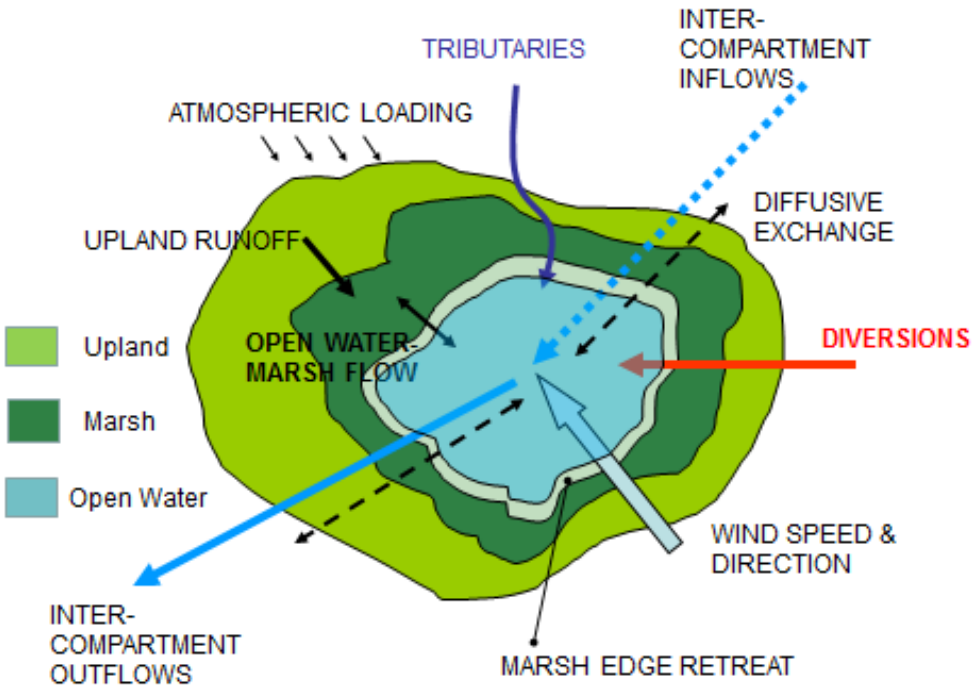
THANK YOU

coastal.la.gov

Ehab Meselhe / emeselhe@thewaterinstitute.org

Sediment Distribution

- Includes:
  - open water sediment processes
  - marsh sediment processes
  - flow & sediment exchange between open water & marsh
- Mass balance based on: mass in, mass out, resuspension, & deposition
- Feedback from marsh edge erosion provides sediment for distribution
- Non-uniform deposition in marsh; particles with higher fall-velocities deposit in near-edge zone (30 m)

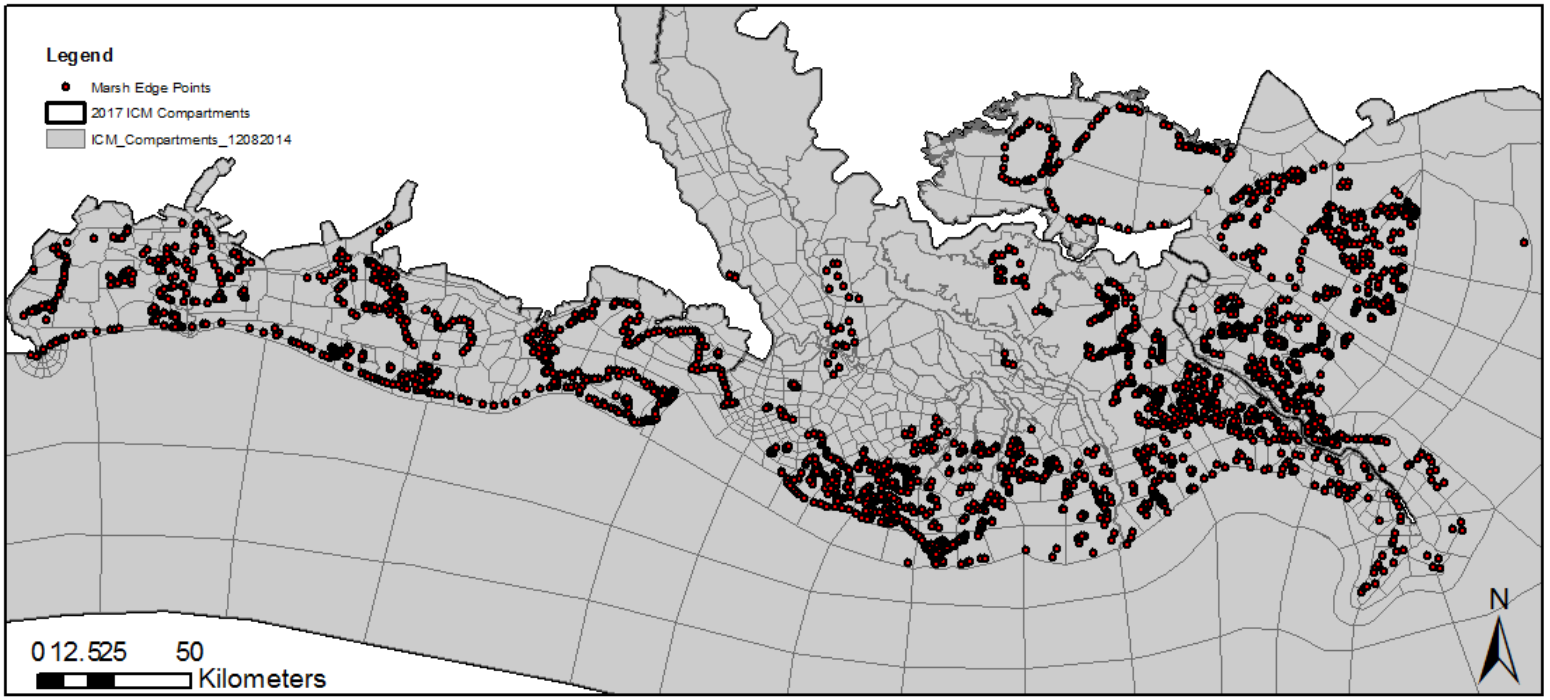


- Procedure for sediment deposition and resuspension, also applied during storm events

Alex McCorquodale, Eric White, Brady Couvillion, Gregg Snedden, Ben Roth

Marsh Edge Erosion

- Marsh edge retreat measurements compiled from aerial imagery from ~2,800 points across coastal LA
- Retreat rates averaged by ICM compartment
- Annual retreat rate is spatially variable, but does not vary in time



Mead Allison, Eric White, Brady Couvillion, Rebekah Jones

Additional Ecosystem Outcomes

- Carbon

- Nitrogen uptake

- Surge and wave attenuation

- Agriculture