Louisiana’s 2012 Coastal Master Plan

CPRA

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Spatial Modeling of Land Change and Relative Elevation to Assess Restoration Priorities in Coastal Louisiana

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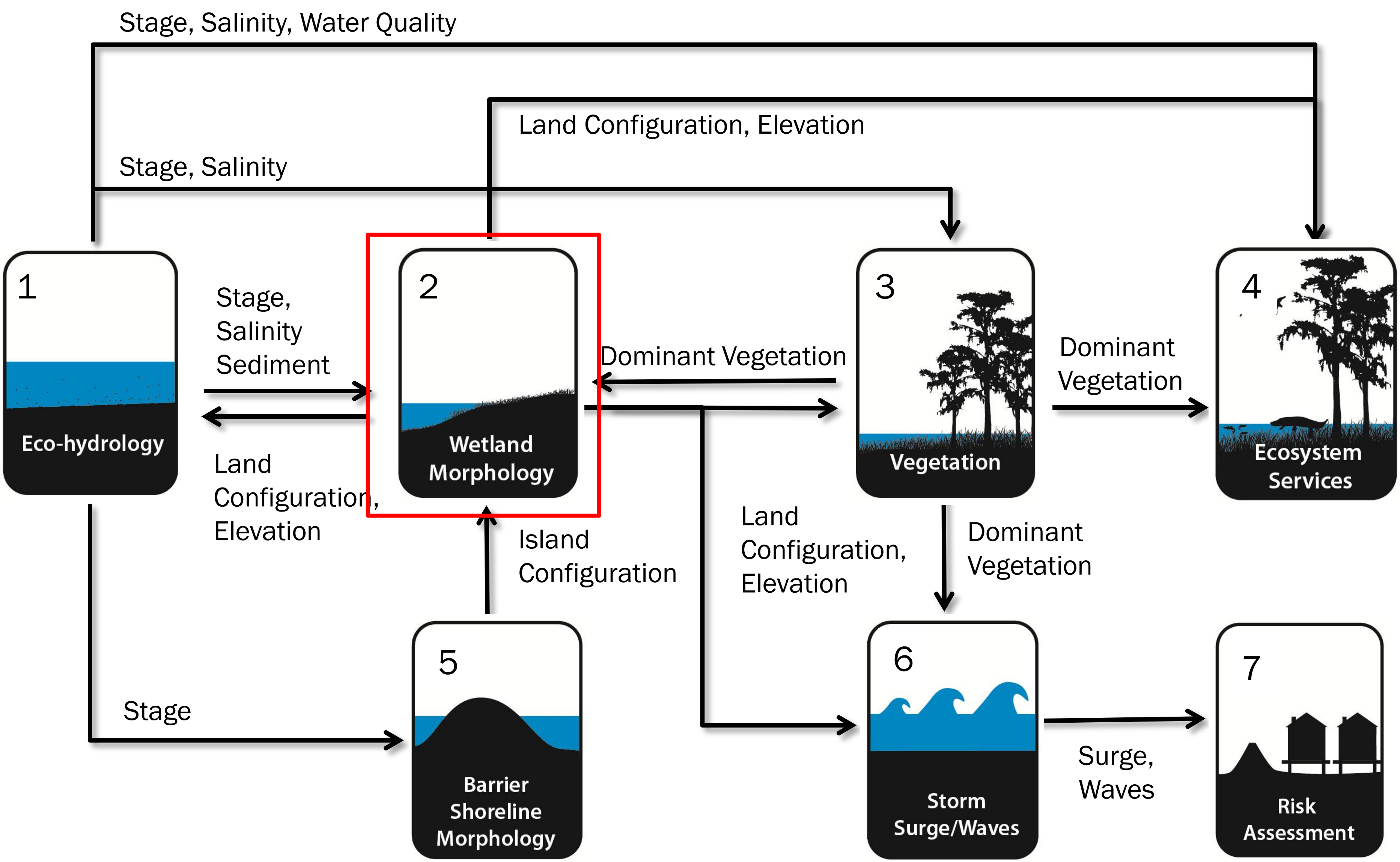
9th INTECOL International Wetlands Conference

Model Overview: Team Members

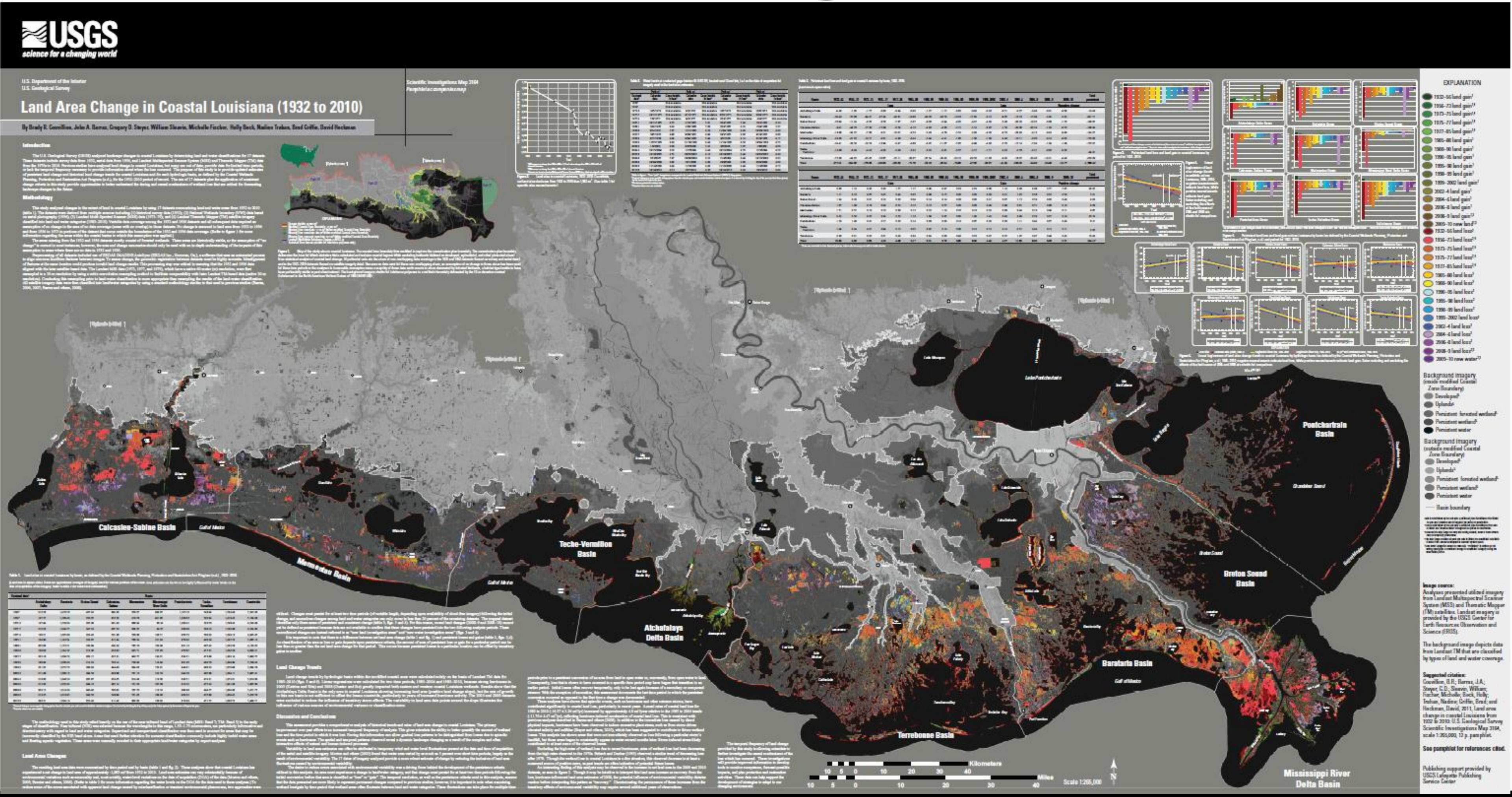
Wetland Morphology

- Greg Steyer, PhD, United States Geological Survey
- Brady Couvillion, United States Geological Survey
- Hongqing Wang, United States Geological Survey
- Bill Sleavin, United States Geological Survey
- John Rybczyk, PhD, Western Washington University
- Nadine Trahan, United States Geological Survey
- Holly Beck, United States Geological Survey
- Craig Fischenich, PhD, United States Army Corps of Engineers - ERDC
- Ron Boustany, Natural Resources Conservation Service
- Yvonne Allen, United States Army Corps of Engineers - ERDC

Modeling in a Systems Context

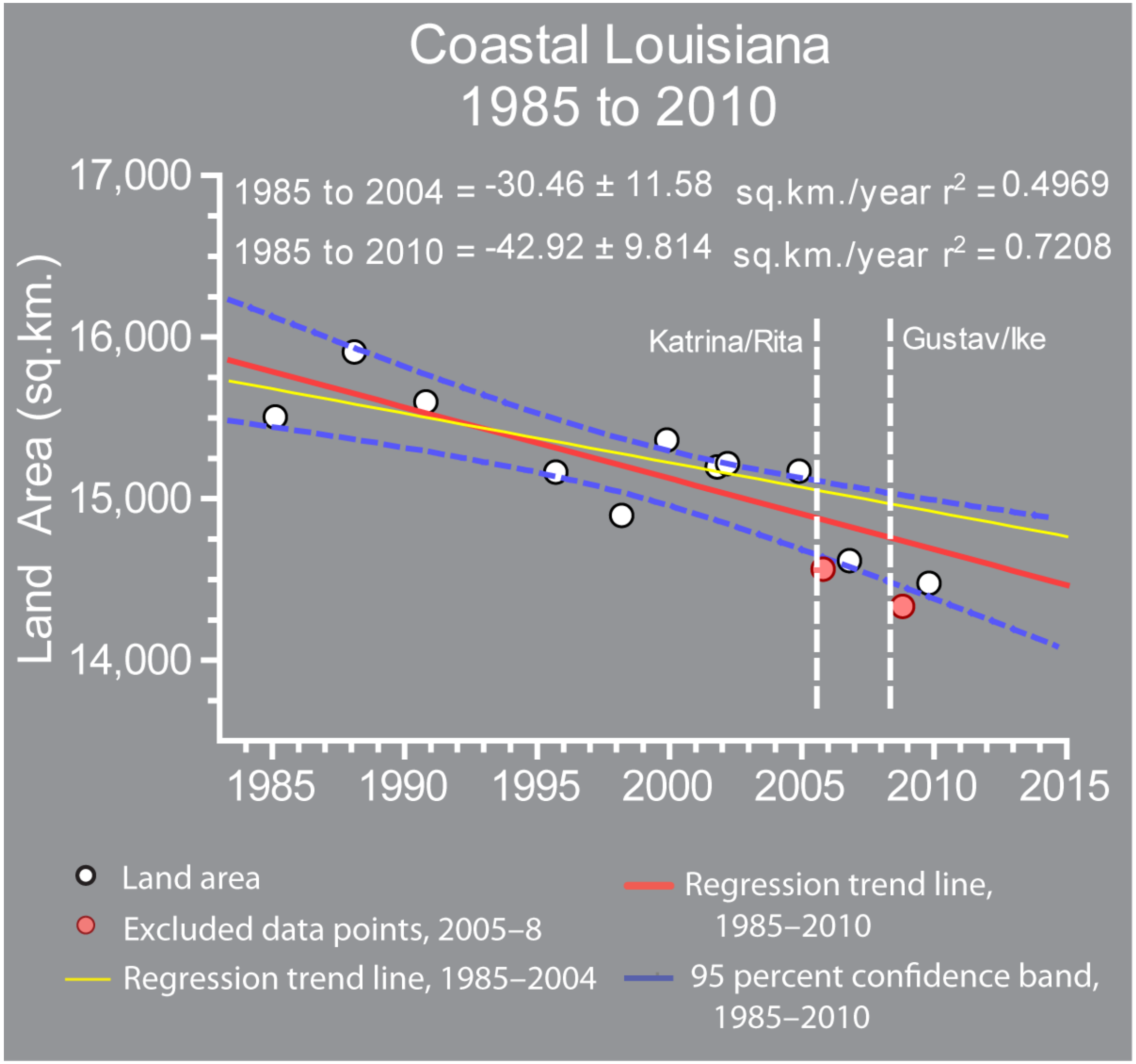


Historic Wetland Change

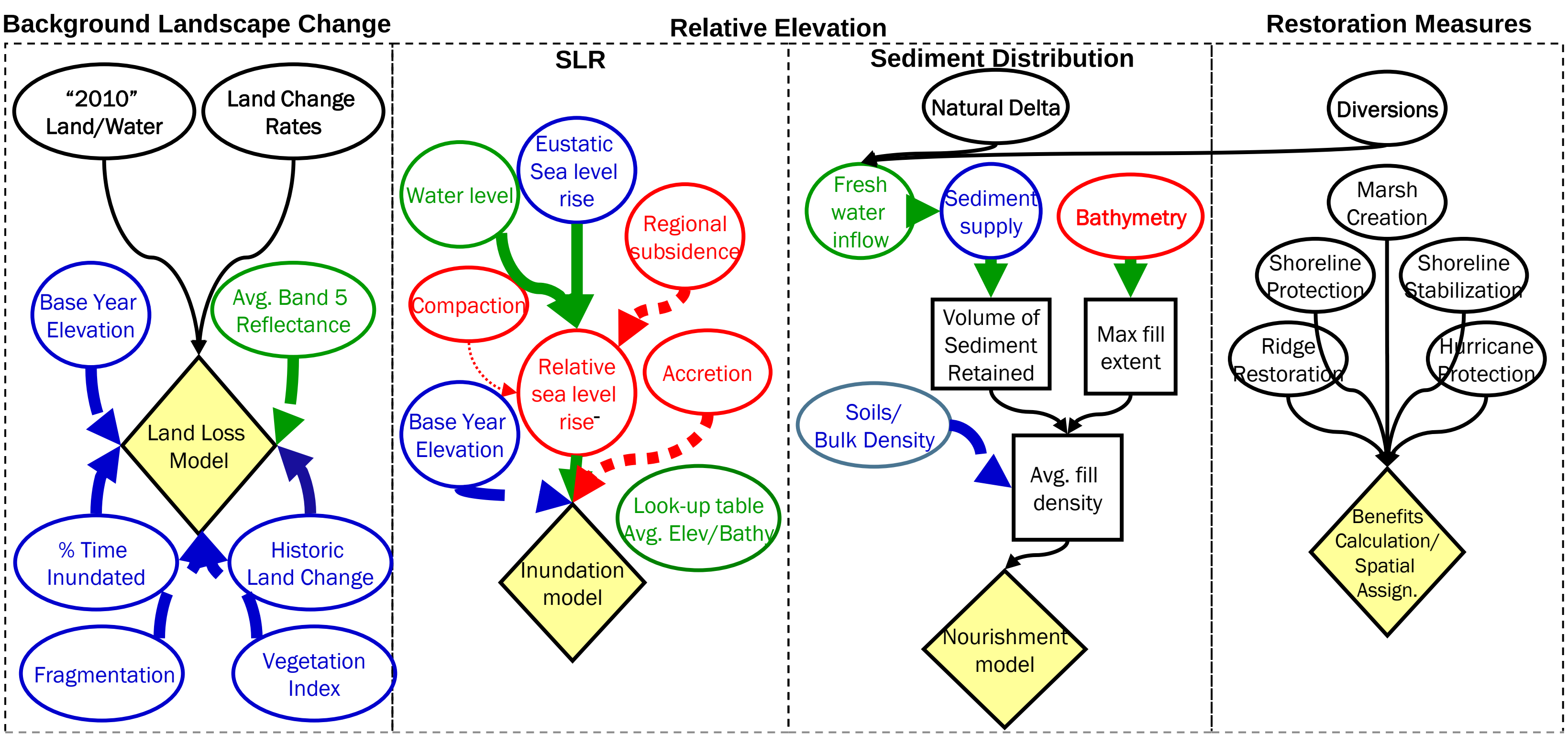


- Net land area change 1932-2010 is 4,877 km^2
- 1985 – 2010 trend is 42.9 km^2/yr

Model Overview: Historic Wetland Change



Wetland Morphology Team - Land Change/Relative Elevation Modules



- Baseline loss rates unassociated with inundation due to RSLR are represented using multi-criteria weighting
- Water depths tracked using mean water level provided by Ecohydro models, SLR and subsidence from uncertainty scenarios, and calculating water depths based on bathy/topo
- The model utilizes a raster-based probability weight and cost surface to distribute sediment within Ecohydro box.
- Surface elevation change relative to water level is tracked in relative elevation model: ΔE = Accretion – ESLR – Subsidence
- Utilize adjusted salinity, water level, and sediment inputs from Eco-hydro to account for project effects

Environmental Scenarios
Uncertainty Ranges and Values

Project performance was evaluated across a range of possible future scenarios (moderate and less optimistic presented) which reflect specific environmental uncertainties that impact coastal planning, including:

- SLR (0.3m; 0.5m),
- Subsidence (spatially variable),
- Mississippi River discharge,
- Rainfall,
- Evapotranspiration,
- Marsh collapse threshold (salinity/inundation).

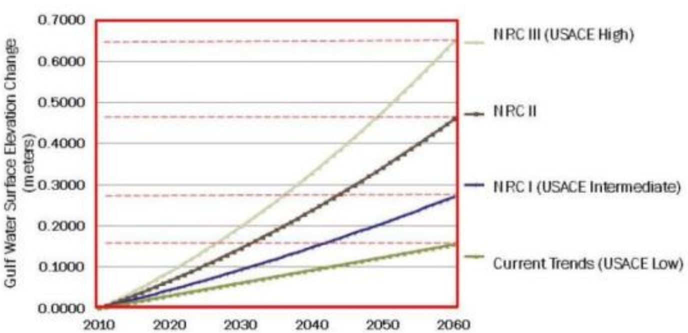
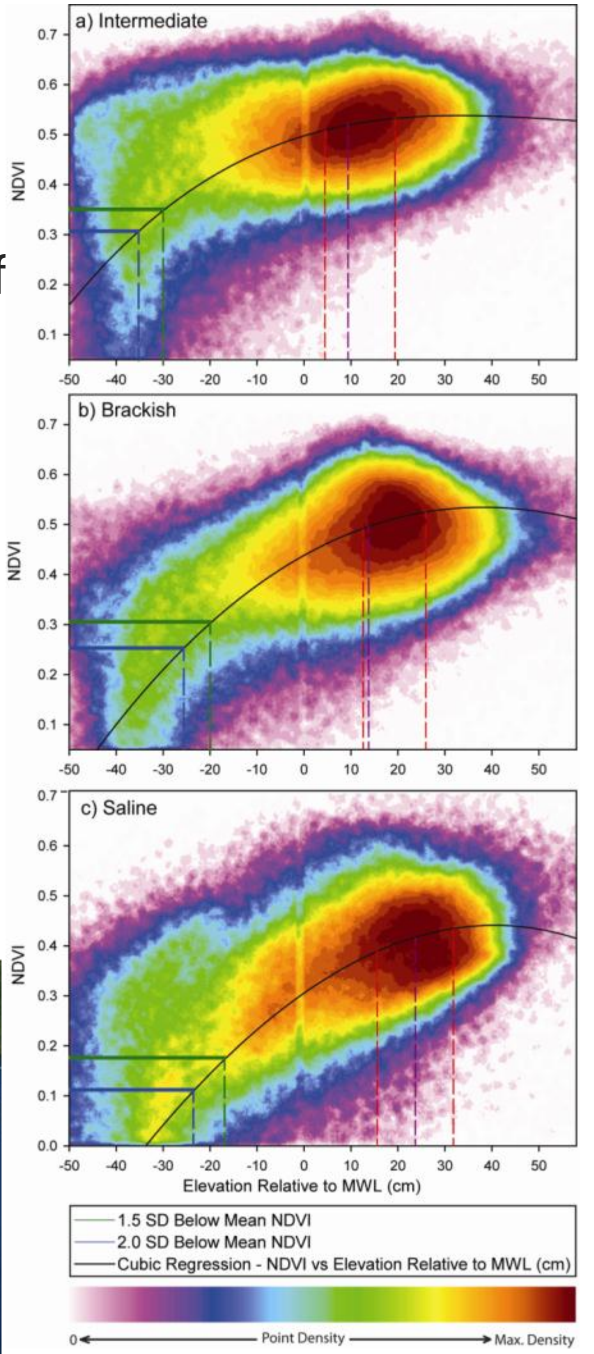


Figure 2. SLR trends from 2010 through 2060.



Model Mechanics: Assumptions

Relative Elevation

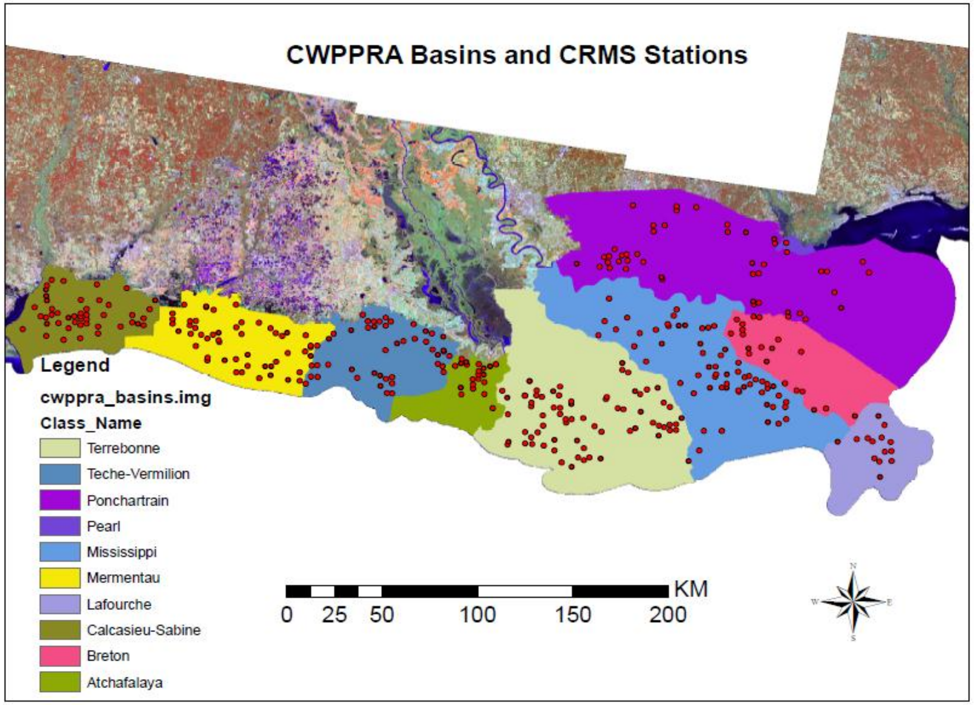
- Organic matter accumulation rate $Q_{org} = Q_{sed} * Org_{frac} / Min_{frac}$ based on fraction of organic matter mass in total soil mass
- Calibrated BD/OM values for each basin-vegtype group are representative and conservative to describe the long-term soil accretionary processes.
- BD assumption that sands settle in open water and fine materials (silts/clay) settle on marsh surface

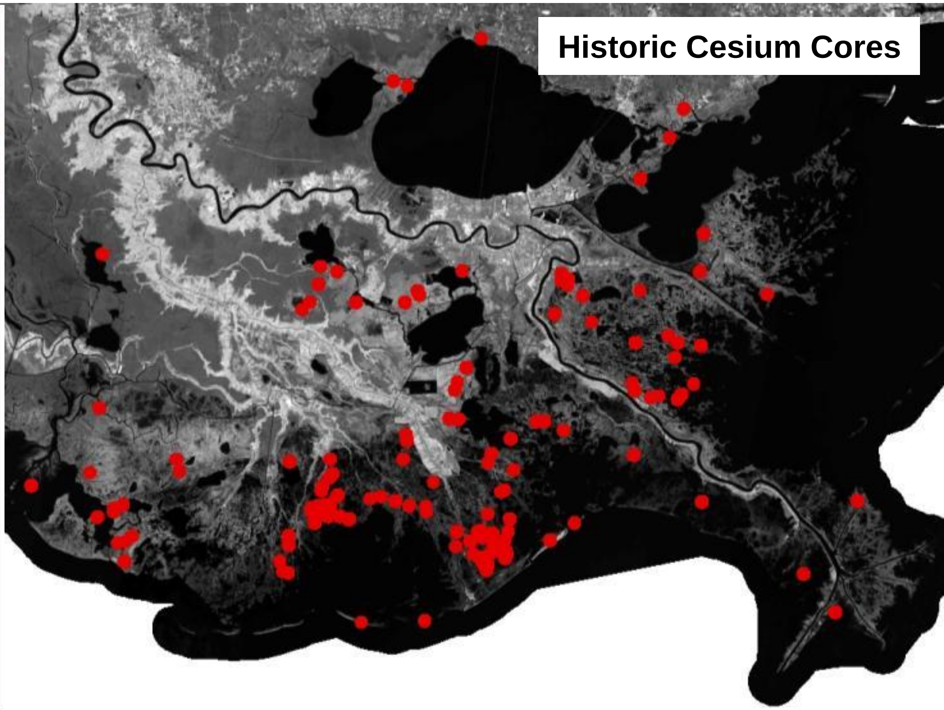
Landscape Change

- With the exception of loss related to RSLR, the model assumes loss related to other factors will continue at rates similar to those observed during the 1984-2010 time period.
- With the exception of loss related to RSLR, land loss is assumed to take place in a linear fashion.
- Assumes 1,000 g/m2/yr delivered to each of the Eco-hydro boxes based on Nyman et al. (1995).
- Sediment delivery to a particular area is limited based on maximum stage exceeding elevation.
- The upper limit of vertical accretion was assumed to be 2.26 cm/yr based on historical field observations across coastal Louisiana (e.g., Rybcyzk 2002; Jarvis 2010).

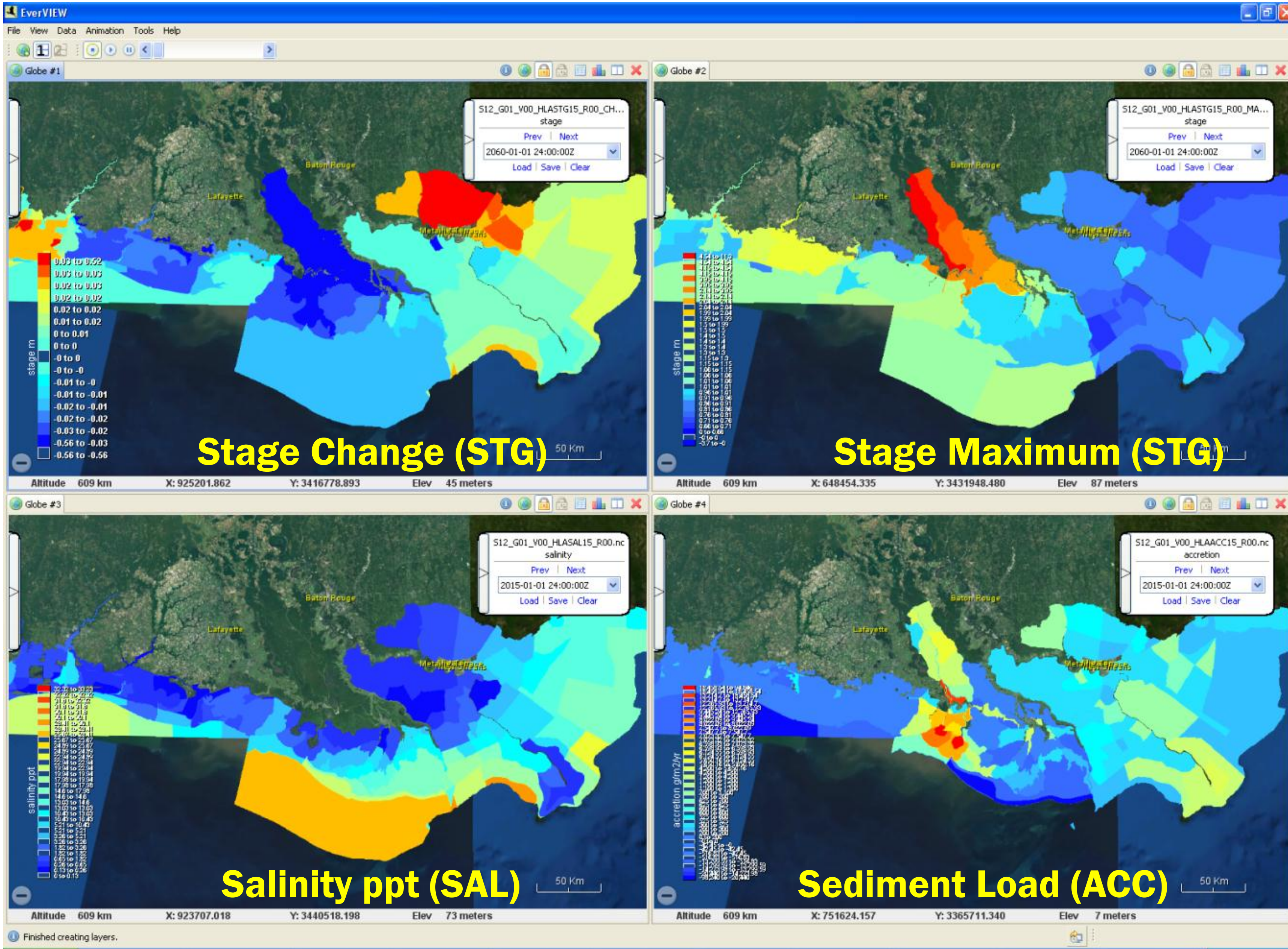
Calibration Data

- **CRMS 2006-2010 soil data (to 24 cm depth): bulk density, OM%, mineral matter %, pore space;**
- **CRMS 2006-2010 soil data: accretion (feldspar) and elevation (SET)**
- **CRMS 2007-2010 hydrology data (salinity and inundation)**
- **CRMS 2007 marsh type classification and dominant species**
- **USDA SURRGO Soils (Soil type, bulk density and OM%)**
- **LCA S&T Task II 2006-2007 data (~50cm depth): BD, OM%, OC%, accretion**
- **Historic Cesium cores (accretion since 1963)**





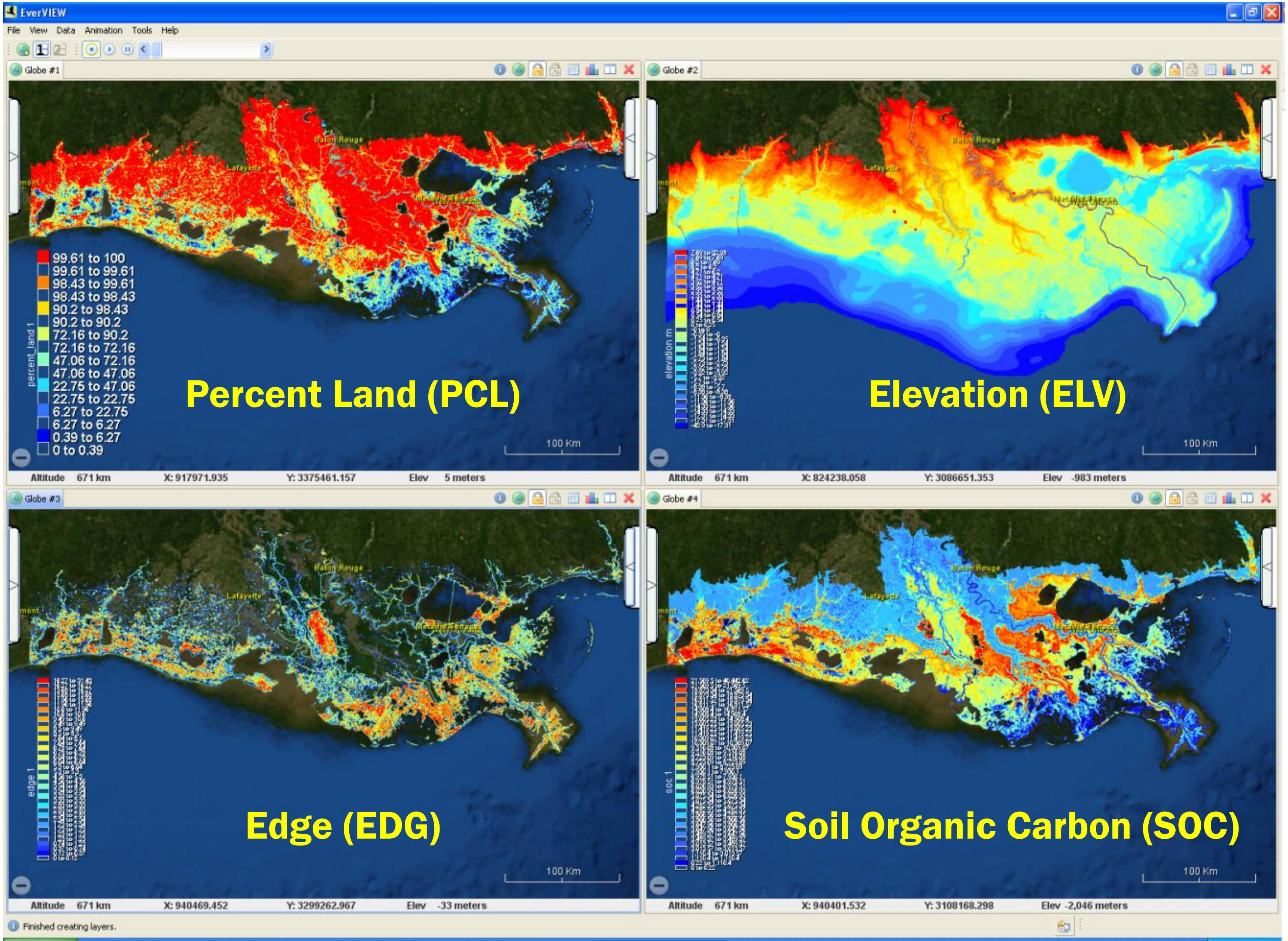
Inputs provided by the Eco-hydrology Team



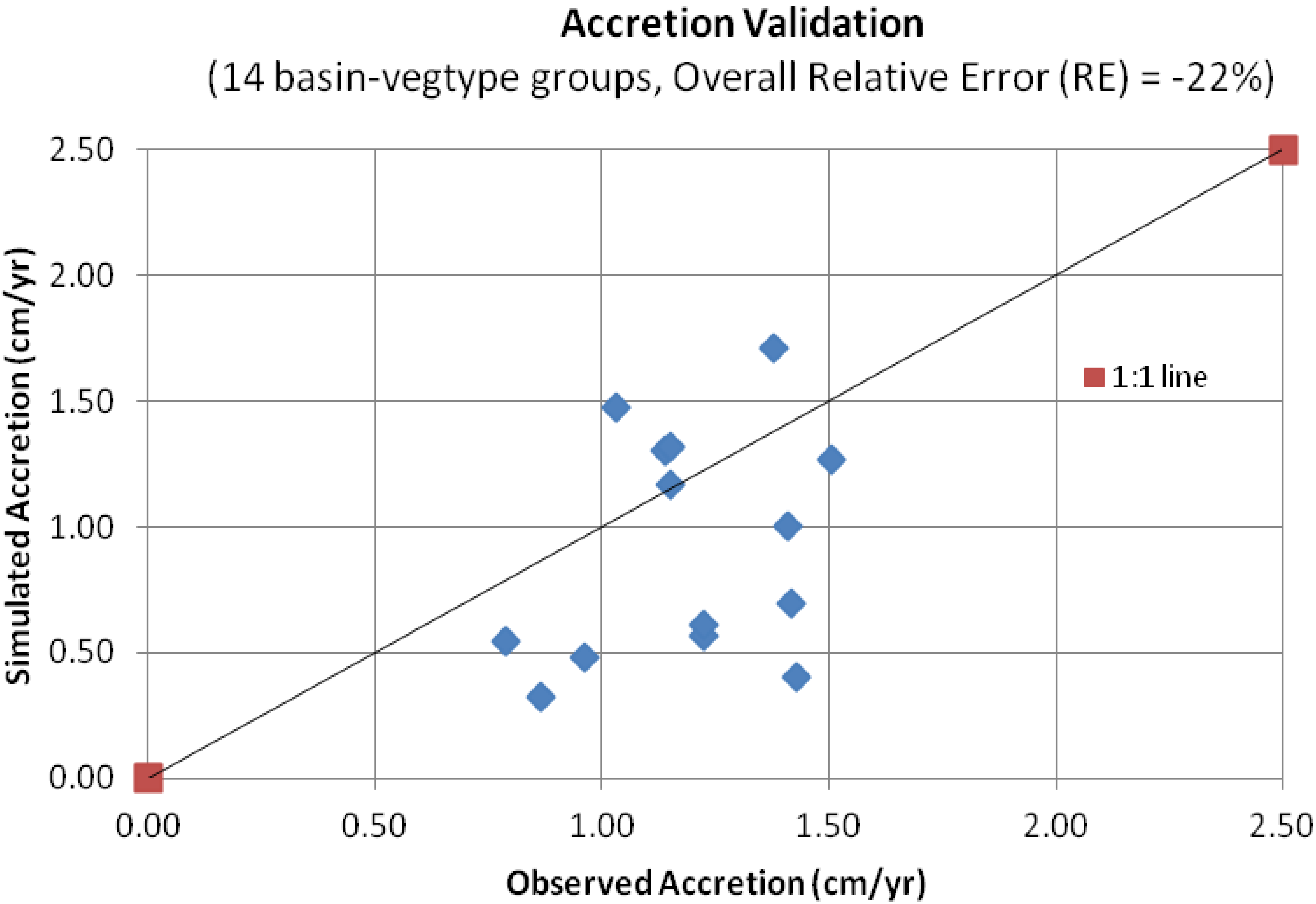
Inputs:


USGS
science for a changing world
DRAFT
Land Use/Land Cover and Wetland Vegetation Community Classification in the northern Gulf of Mexico: 2009
Taxodium distichum
Salix nigra
Colocasia Esculenta
Zizaniopsis miliacea
Typha
Panicum hemitomon
Eleocharis cellulosa
Cladium jamaicense
Phragmites australis
Schoenoplectus americanus
Sagittaria lancifolia
Spartina patens
Paspalum vaginatum
Distichlis spicata
Spartina alterniflora
Legend

Results: Model Outputs



Validation

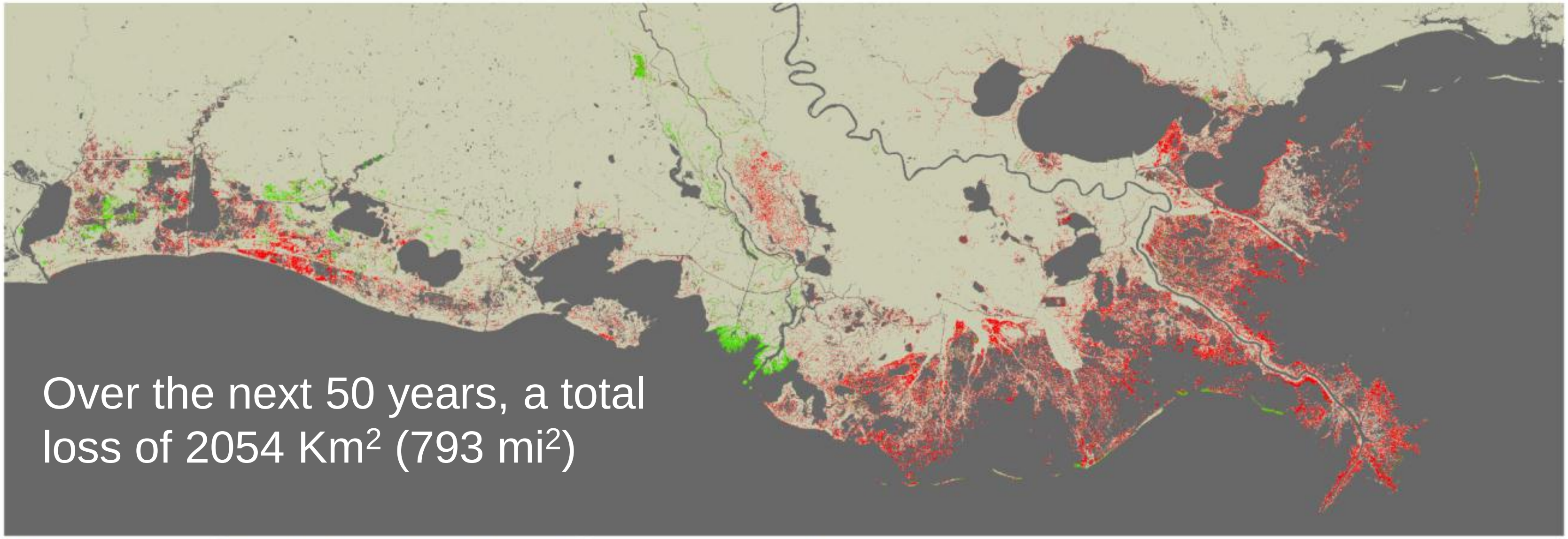


Accretion Validation
(14 basin-vegtype groups, Overall Relative Error (RE) = -22%)
2.50
2.00
1.50
1.00
0.50
0.00
Simulated Accretion (cm/yr)
1:1 line
0.00
0.50
1.00
1.50
2.00
2.50
Observed Accretion (cm/yr)

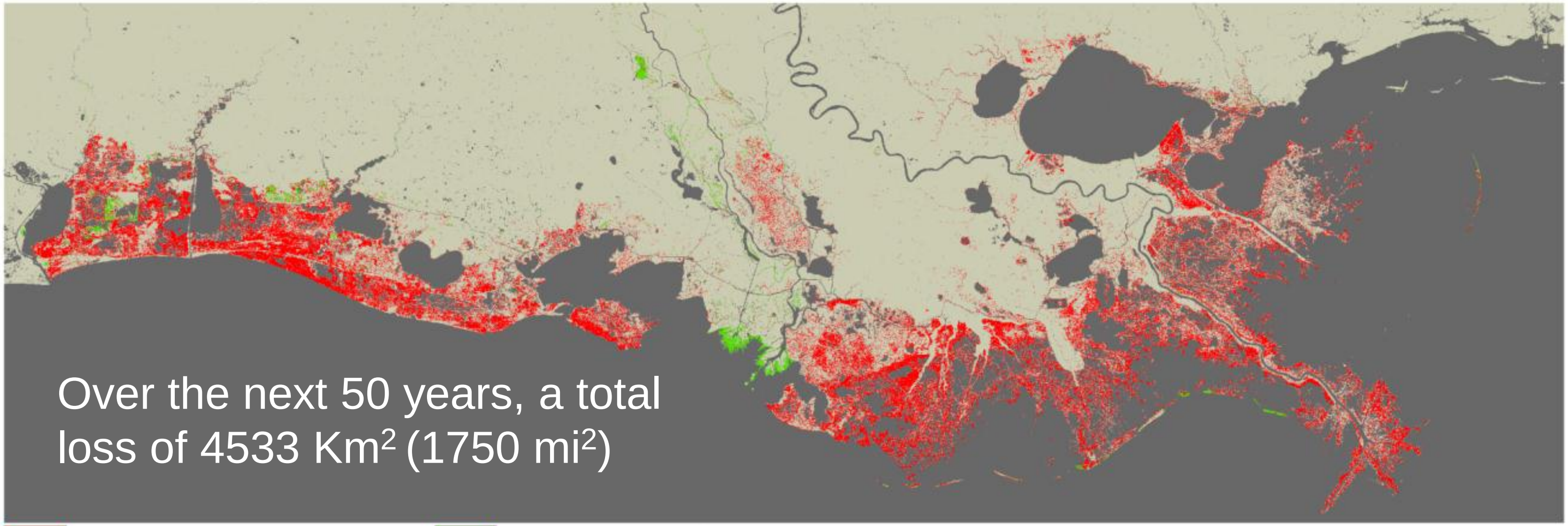
Validation: Future without Action - Moderate Scenario

Basin	Modeled Accretion (cm/yr) Mean	Accretion Range from Literature (cm/yr)	Source
Calcasieu/Sabine	**0.283**	0.36-0.9	DeLaune et al., 1989; Bryant & Chabreck, 1998; Steyer, 2008
Mermentau	**0.536**	0.12-0.98	Cahoon, 1994; Bryant & Chabreck, 1998
Teche/Vermilion	**0.578**	0.29-0.70	Bryant & Chabreck, 1998
Atchafalaya	**1.600**	??-2.06	Day et al., 2011
Terrebonne	**0.660**	0.07-0.99	DeLaune et al., 1989; Nyman et al., 1993
Barataria	**0.891**	0.59-1.4	Hatton et al., 1983; DeLaune et al., 1989
Mississippi River Delta	**0.733**	Not Available	NA
Breton Sound	**0.874**	0.42-1.72	DeLaune et al., 2003
Pontchartrain	**0.668**	Not Available	NA
LA Coastwide	**0.689**	0.25-1.78	Nyman & DeLaune, 1999
		0.46-0.76	Piazza et al., 2011
		0.59-0.98	Nyman et al., 2006

Moderate Scenario

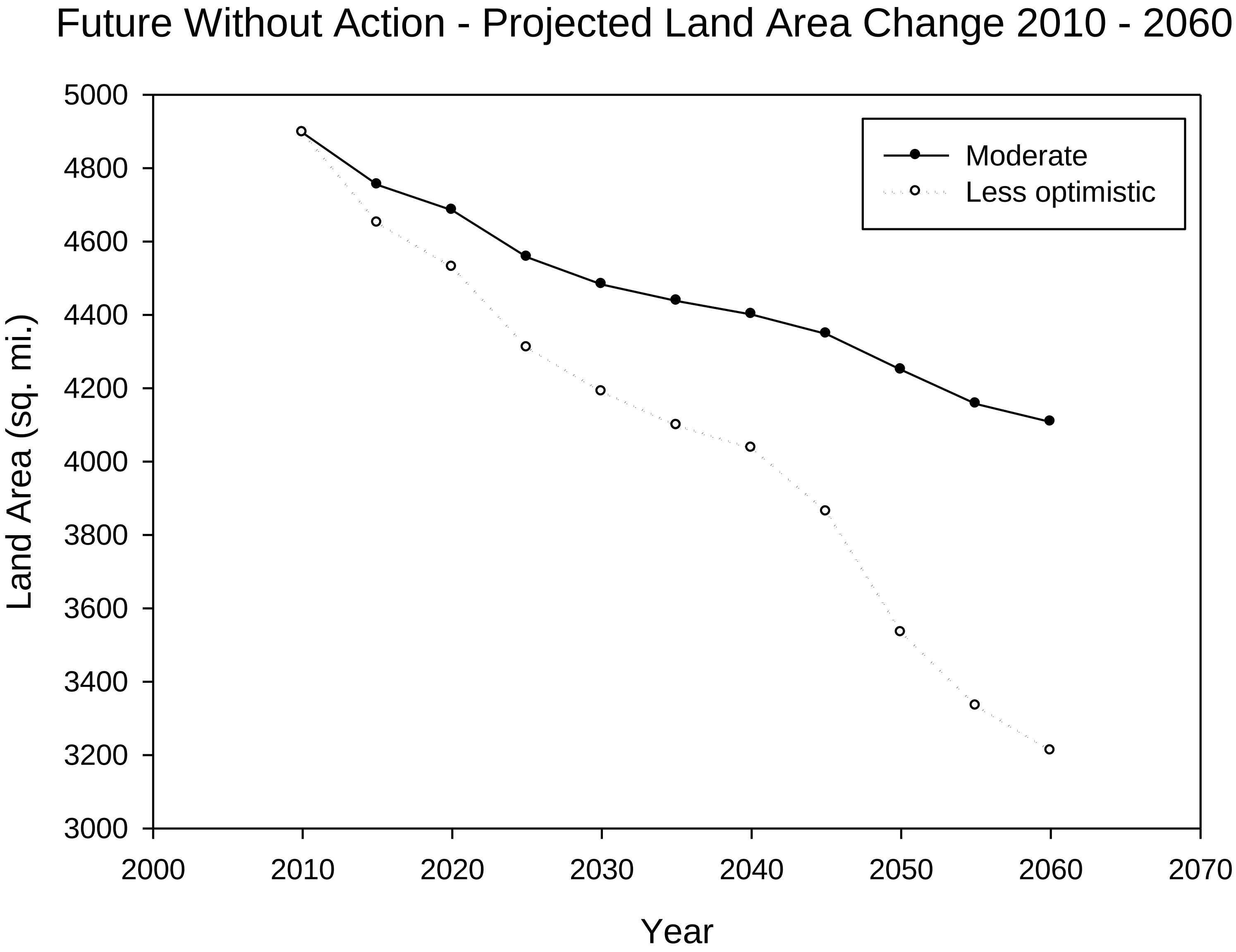


Less Optimistic Scenario

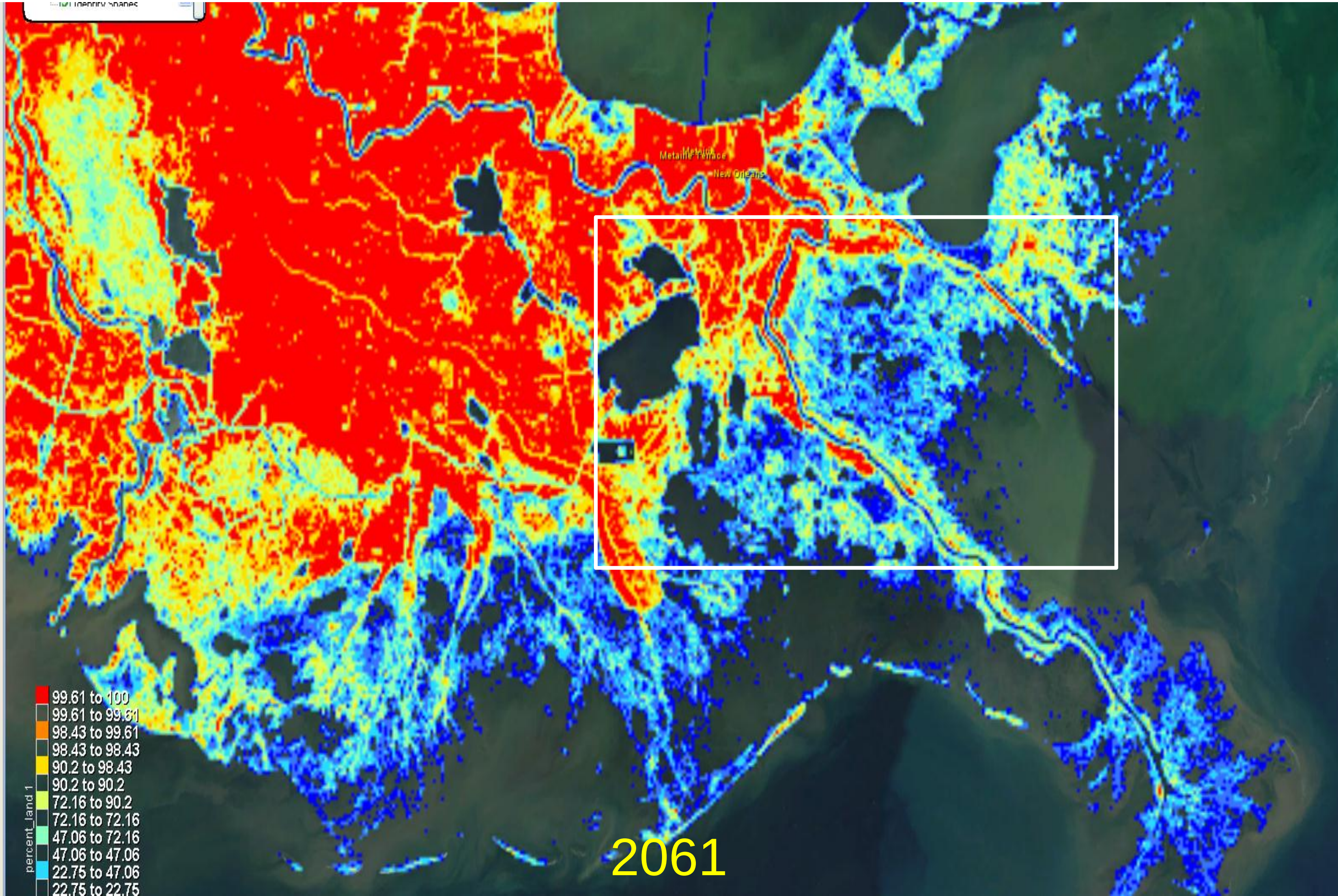


Potential Wetland Loss 2010-2060 Potential Wetland Gain 2010-2060

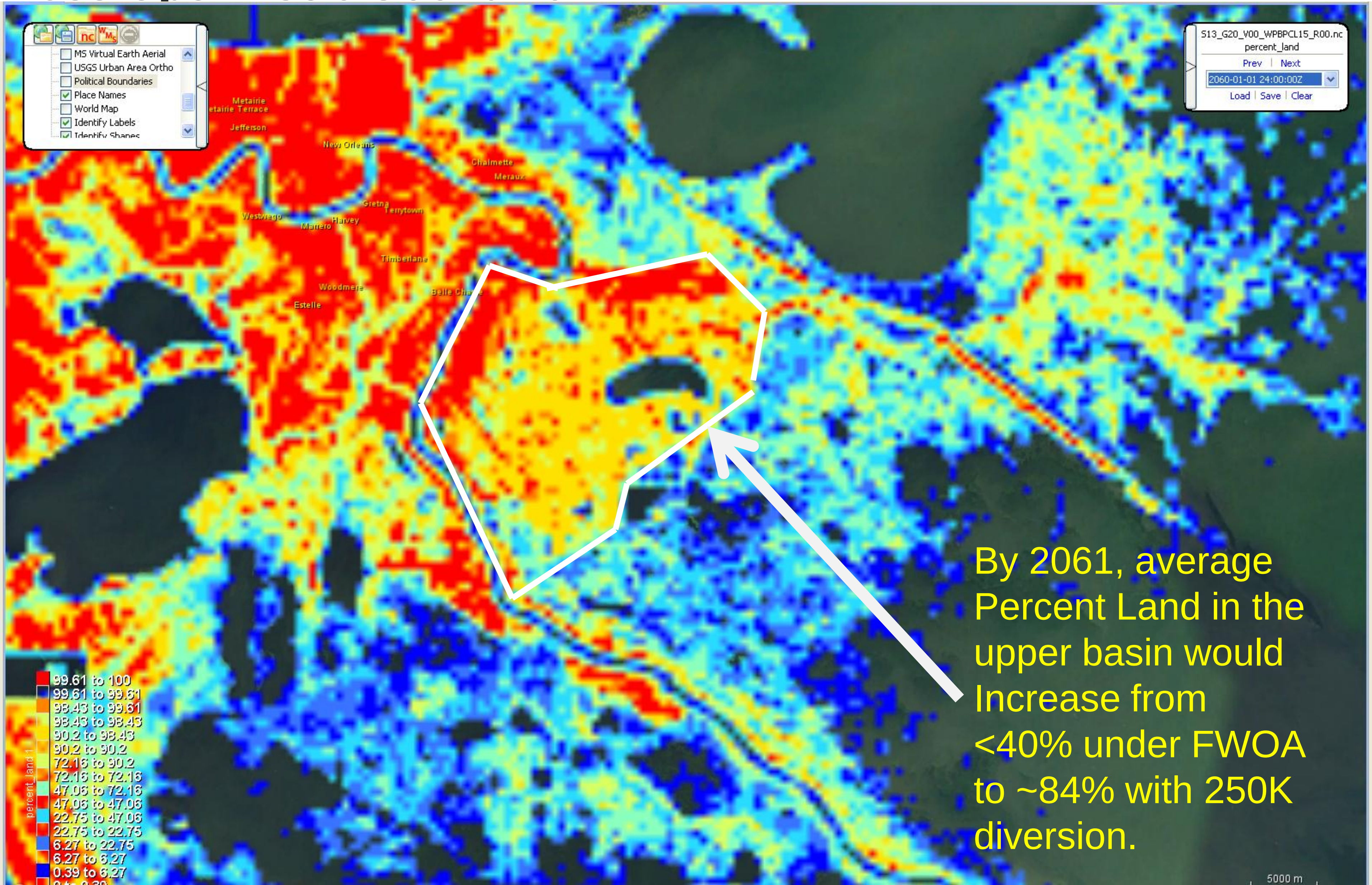
Results: Potential Land Area Change



Results: Percent Land: FWOA – Moderate Scenario

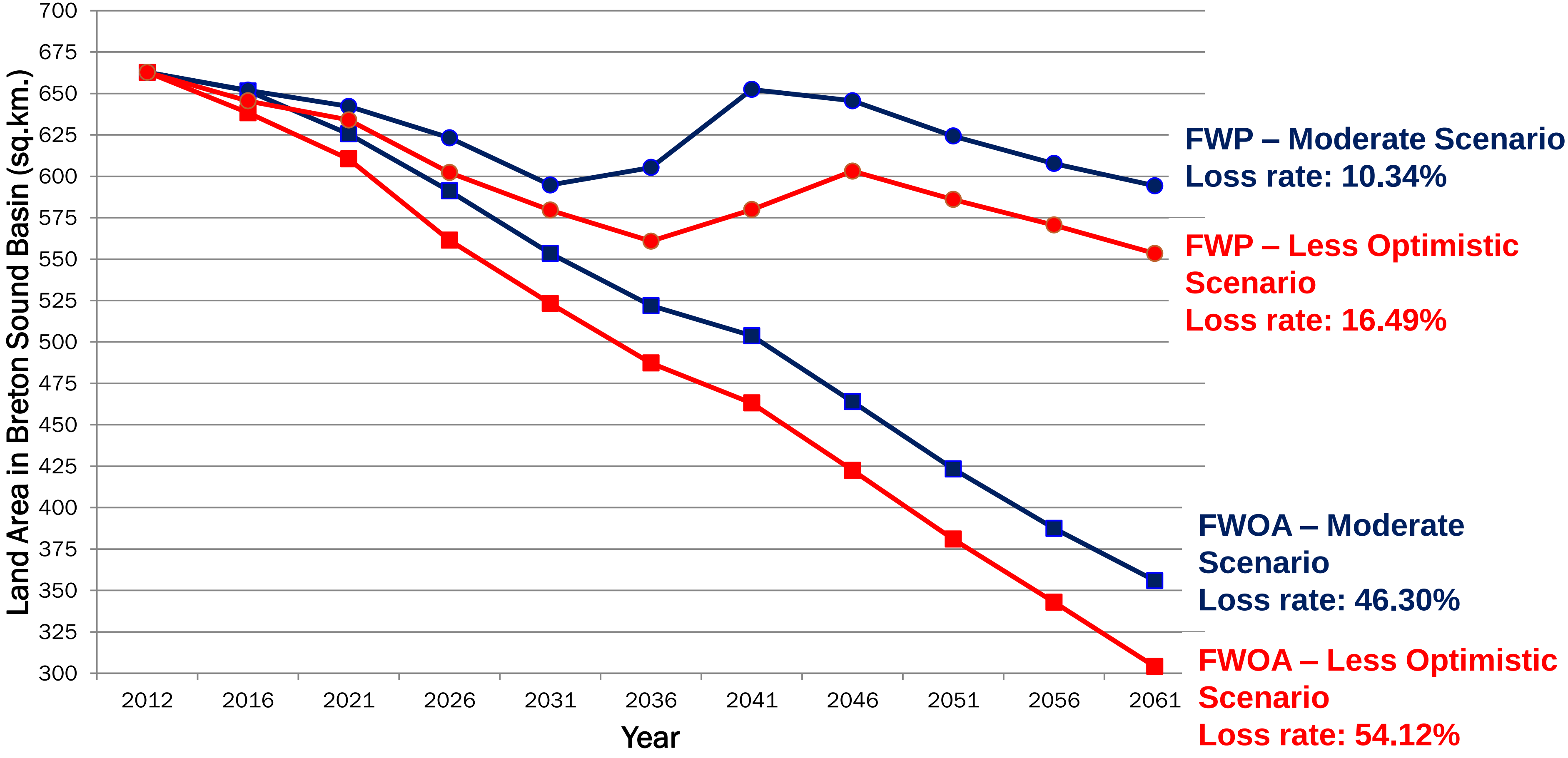


Results: Model Outputs: Upper Breton Diversion (max 250K cfs) Less Optimistic Scenario



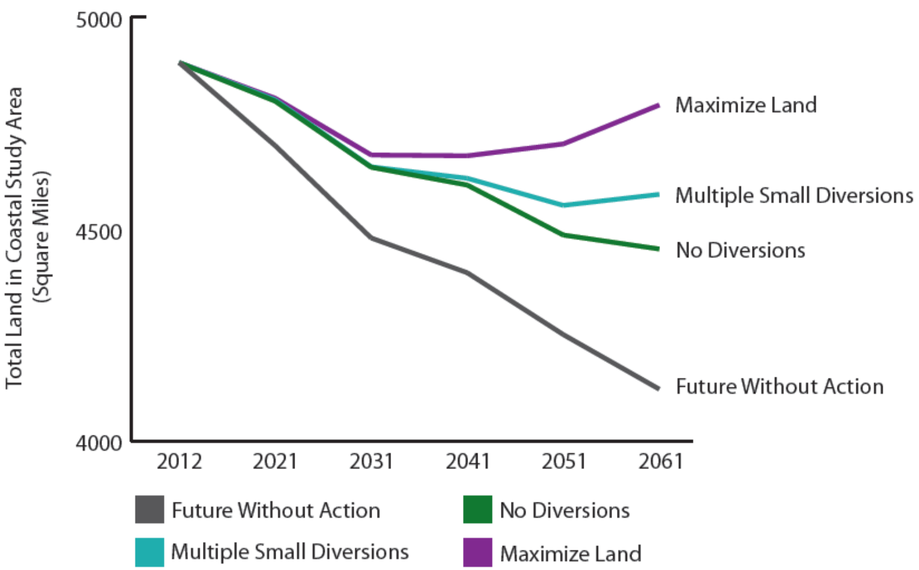
By 2061, average Percent Land in the upper basin would Increase from <40% under FWOA to ~84% with 250K diversion.

Results: Model Outputs: Upper Breton Diversion (max 250K cfs) Moderate and Less Optimistic Scenarios

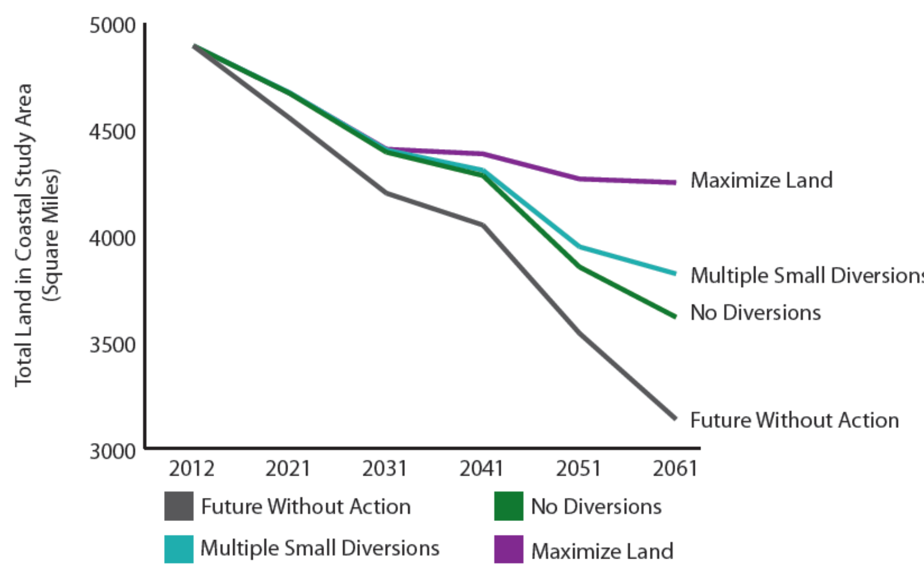


Potential Land Area Change

Potential Land Area Change Over Next 50 Years
Moderate Scenario



Potential Land Area Change Over Next 50 Years
Less Optimistic Scenario



Strengths

- **Addresses uncertainties.**
  - Eustatic sea- level rise [ESLR],
  - Subsidence
  - Freshwater and mineral sediment supply
  - Marsh Collapse Thresholds
- **Directly incorporates the affect of accretion on landscape change projections.**
  - Improves upon so-called “bathtub” model projections by considering wetland elevation maintenance through accretion
- **Enables the projection of changes in elevation which can then be utilized by other models.**
- **Can be used to project soil organic carbon sequestration under RSLR and restoration.**

Limitations

- Effectively address how much sediment is delivered to the marsh surface at finer resolutions than the box scale
- Reflect the spatial variation in sediment accumulation brought by hurricanes/storms of different categories.
- Estimate vertical soil loss depth by erosive forces (e.g., wind/wave at marsh open water interface and by biological factors e.g., vegetation mortality).
- Capture OM inputs from wetland productivity and elevation change based on changes in below-ground processes

Next Steps

- **Further testing of multi-criteria weightings of marsh loss**
- **Distribution of sediment to marsh surface**
  - More spatially explicit sediment transport model
- **Spatially-distributed sediment delivery from hurricanes**
  - Inclusion of variable storm surge sedimentation rate across coast for modeled storms scaled to surge water depth and based on maximum sedimentation from literature
- **Changes in bulk density associated with restoration**
  - Temporal - Marsh creation (Bayou LaBranche 1.16 – 0.6 in 6 yrs)
- **Feedback between eco-hydrology, vegetation, and landscape/elevation modeling**
  - At five-year interval (currently at 25-year interval)
  - Coupling for efficiency

Thank You!