Pathways at the coastal land margin to assess climate change impacts with transdisciplinary research outcomes

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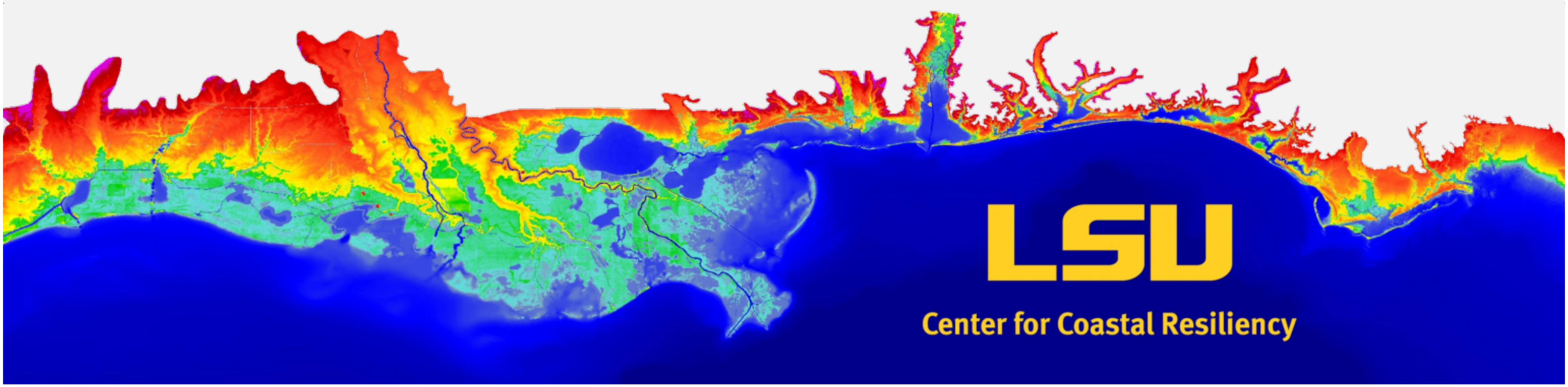

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My CCR Collaborators . . .

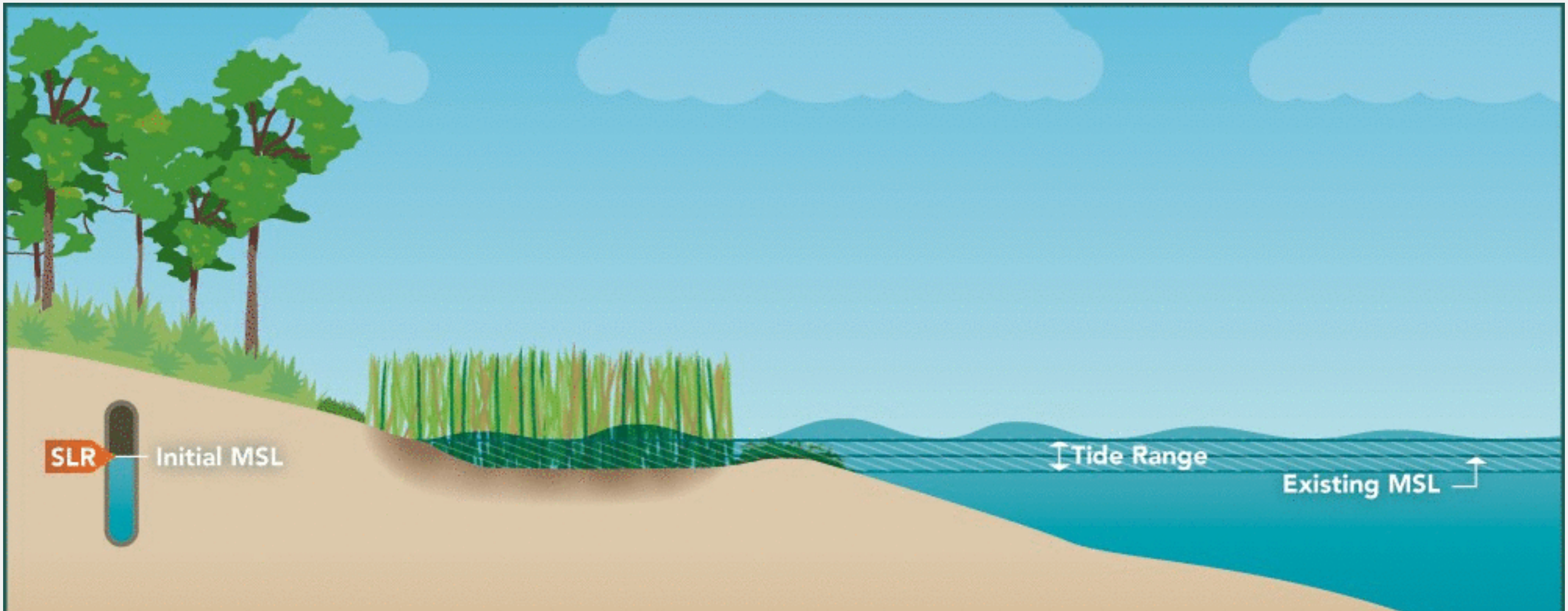
. . . on this research

ADCIRC & Science Collaborators: Karim Alizad, Louisiana State University
Matthew Bilskie, Louisiana State University
Stephen C. Medeiros, University of Central Florida
Davina Passeri, USGS

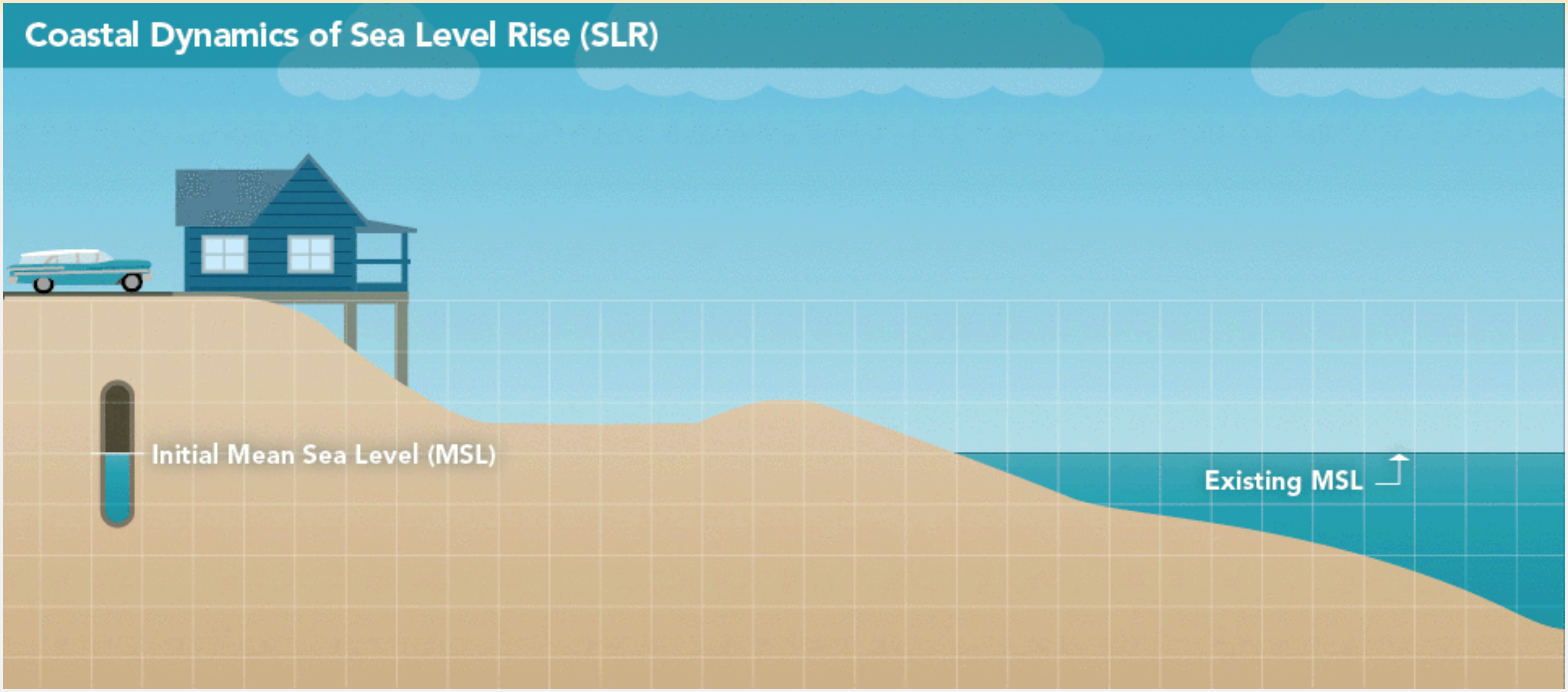
Science Collaborators: Christine Buckel, NOAA
Renee Collini, Dauphin Island Sea Lab / NGOM SSC
Denise E. DeLorme, Louisiana State University
James T. Morris, University of South Carolina
Nathaniel Plant, USGS
David Yoskowitz, Texas A&M University-Corpus Christi


100 million million meters
10^{14}
meters

Coastal dynamics of SLR and a salt marsh

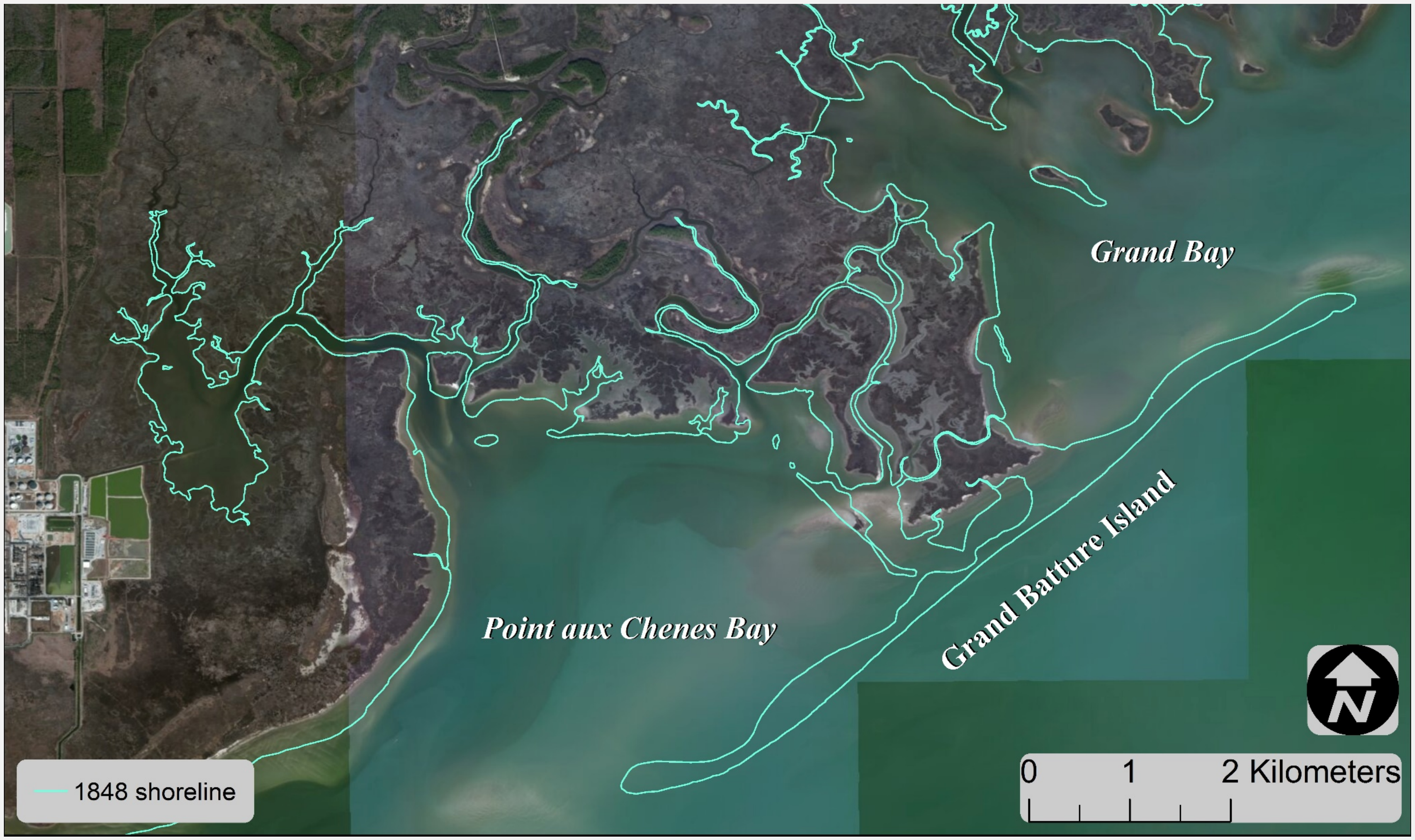


Passeri, D. L., et al, (2015), The dynamic effects of sea level rise on low-gradient coastal landscapes: A review, *Earth's Future*, 3(6), 159-181, http://dx.doi.org/10.1002/2015EF000298.



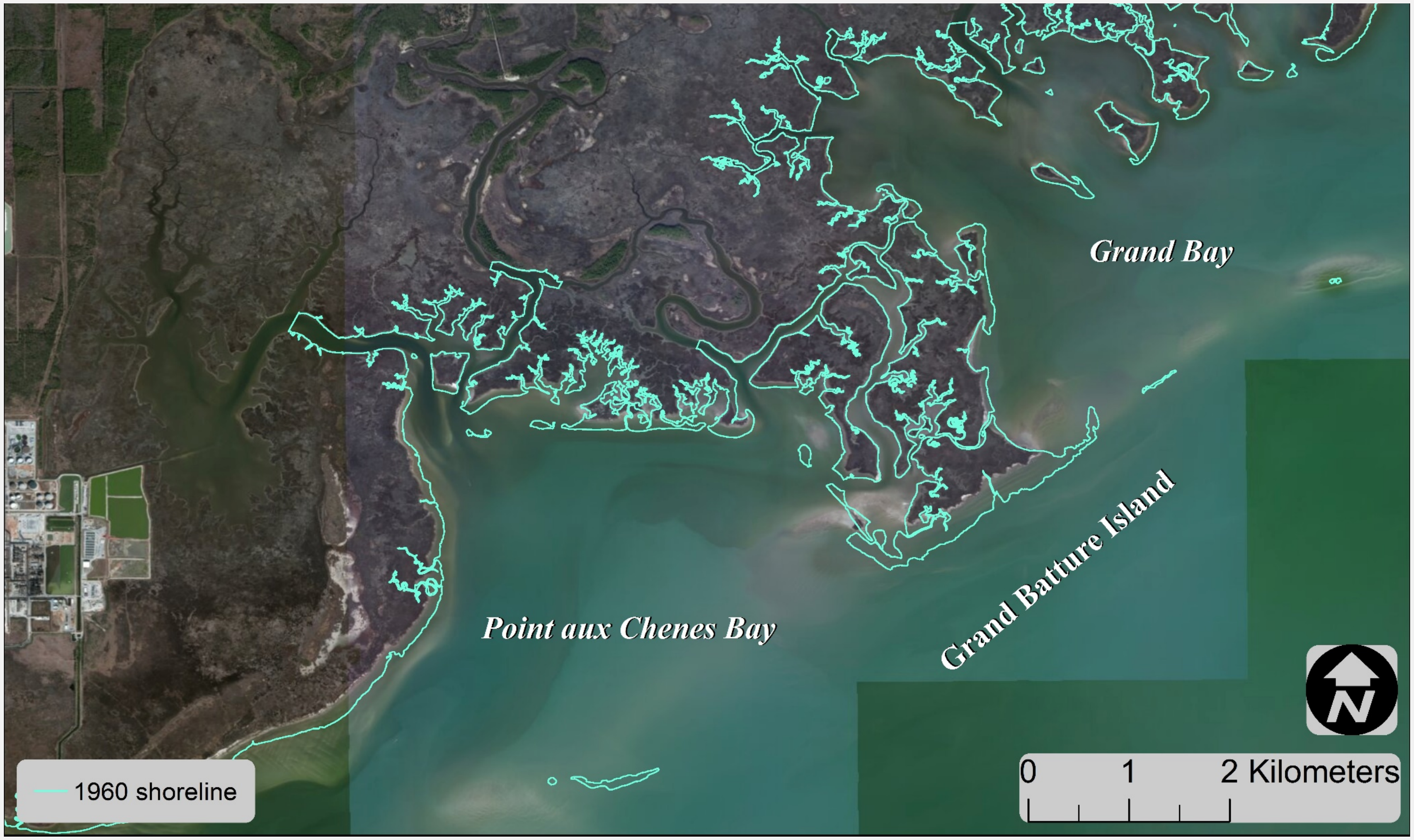
Passeri, D. L., et al, (2015), The dynamic effects of sea level rise on low-gradient coastal landscapes: A review, Earth's Future, 3(6), 159-181, http://dx.doi.org/10.1002/2015EF000298.

1848 Shoreline – Grand Bay



Passeri, D.L. & S.C. Hagen, et al. "Impacts of historic morphology and sea level rise on tidal hydrodynamics in a microtidal estuary (Grand Bay, Mississippi)." *Continental Shelf Research*, Vol. 111, pp. 150-158, 2015. http://dx.doi.org/10.1016/j.csr.2015.08.001

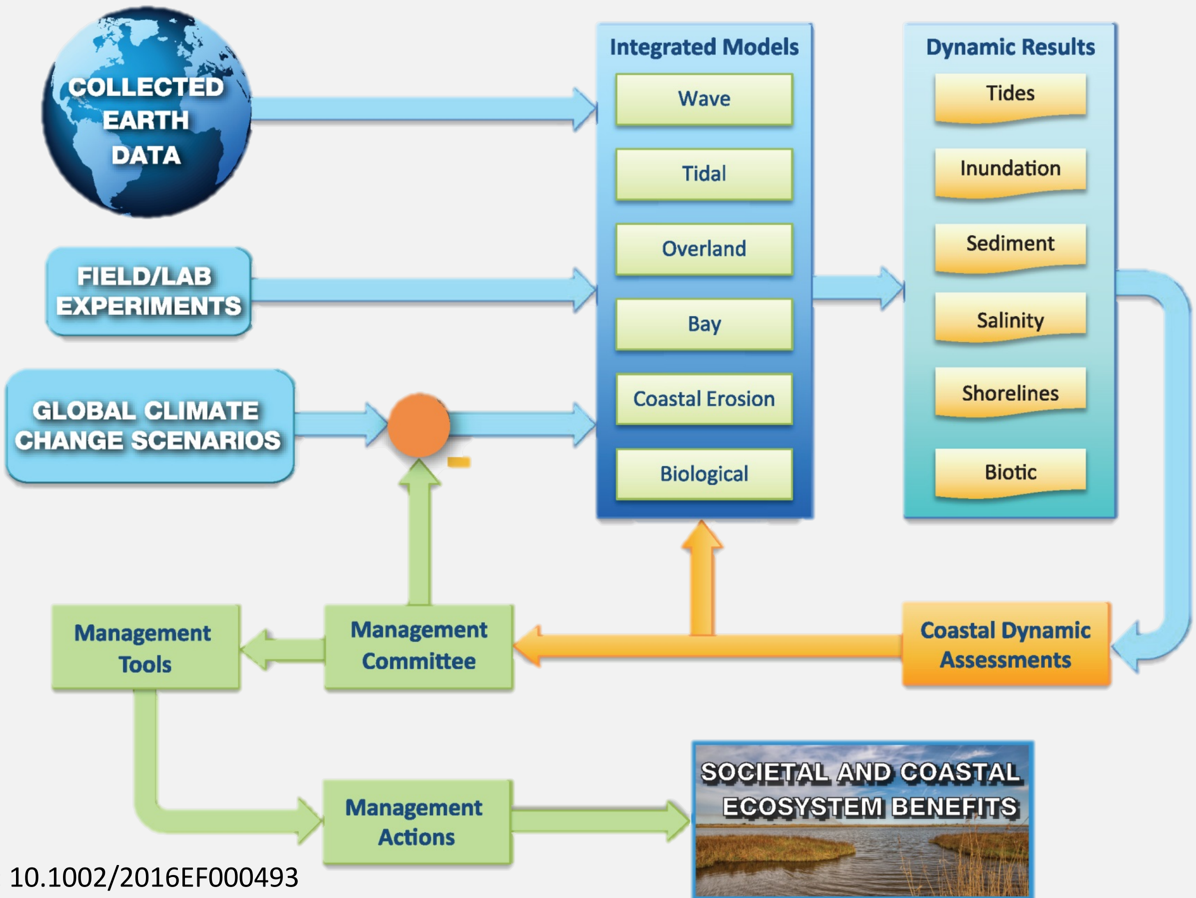
1960 Shoreline – Grand Bay



Passeri, D.L. & S.C. Hagen, et al. "Impacts of historic morphology and sea level rise on tidal hydrodynamics in a microtidal estuary (Grand Bay, Mississippi)." *Continental Shelf Research*, Vol. 111, pp. 150-158, 2015. http://dx.doi.org/10.1016/j.csr.2015.08.001

A Process Diagram for the Coastal Dynamics of Sea Level Rise

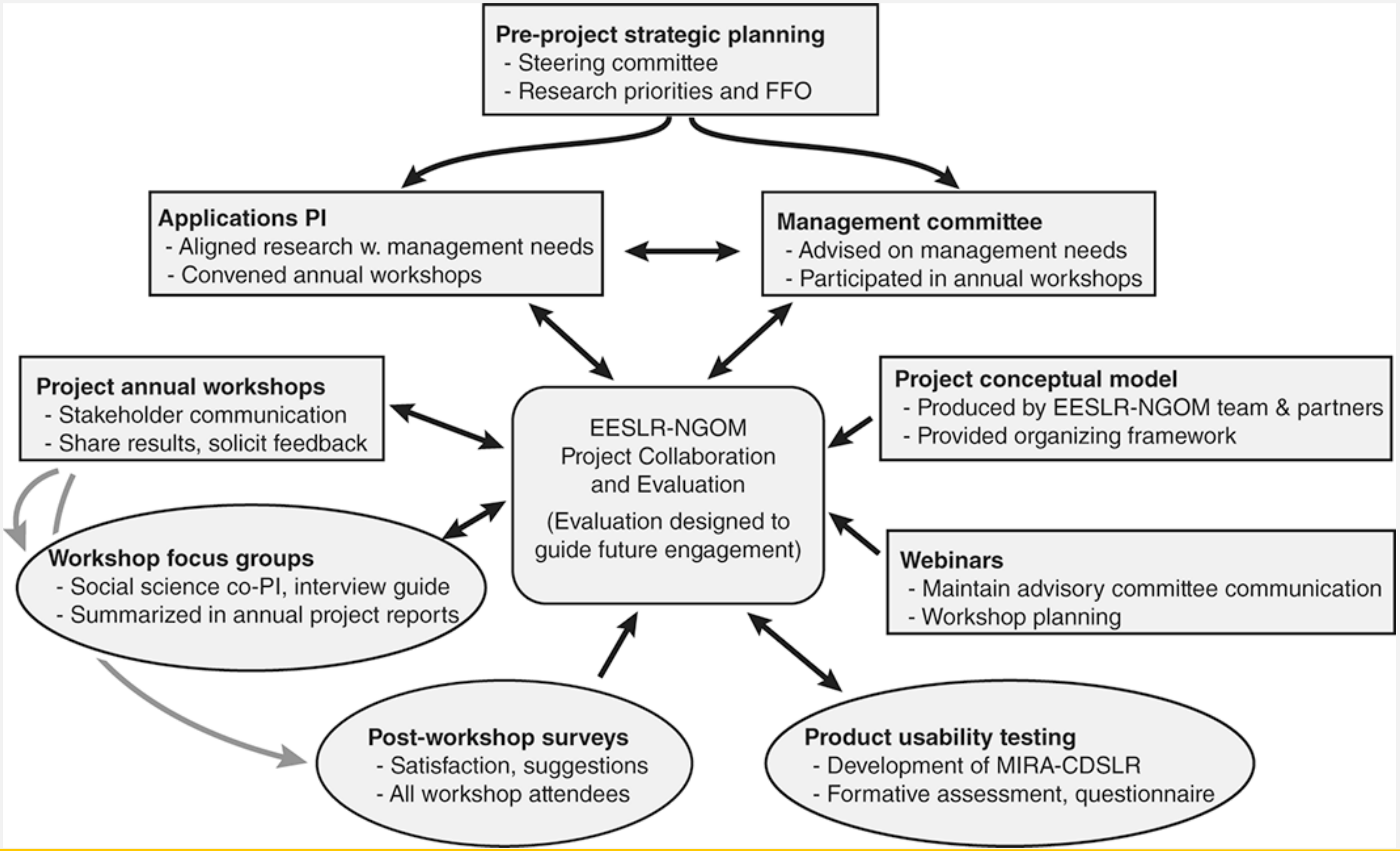
We have contributed to a shift in the paradigm of how climate change in general and sea level rise in particular is assessed at the coastal land margin. With a system of systems approach we can evaluate the coastal dynamics of sea level rise.



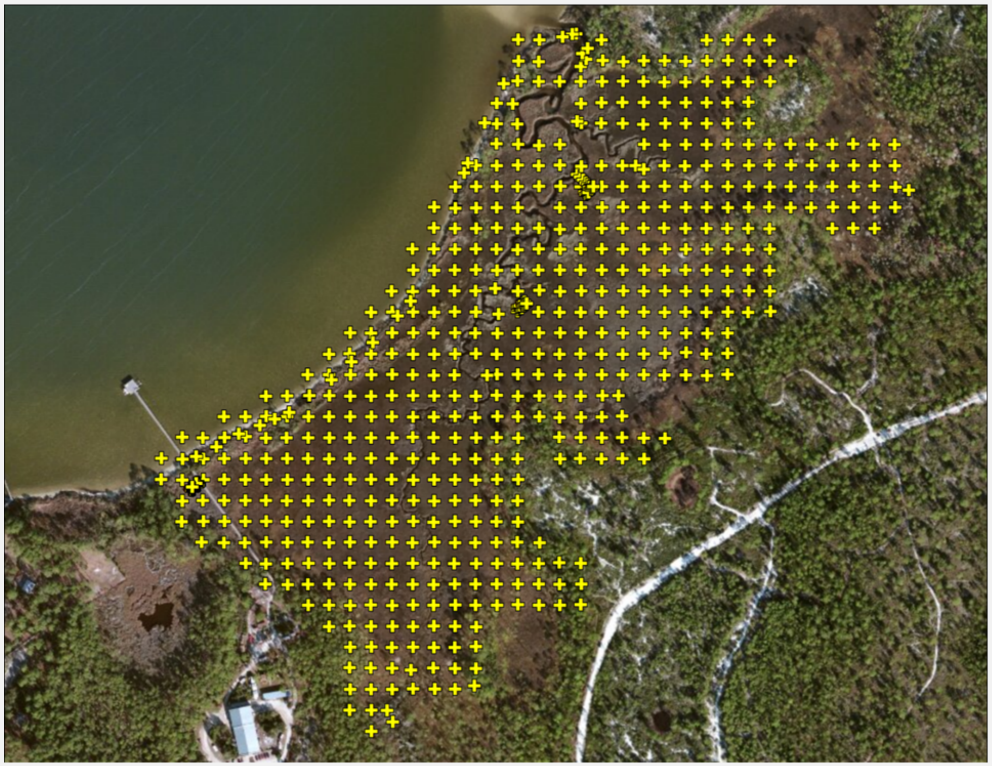
Earth's Future Volume 5, Issue 1, pages 2-9, 20 JAN 2017 DOI: 10.1002/2016EF000493
http://onlinelibrary.wiley.com/doi/10.1002/2016EF000493/full#eft2177-fig-0002

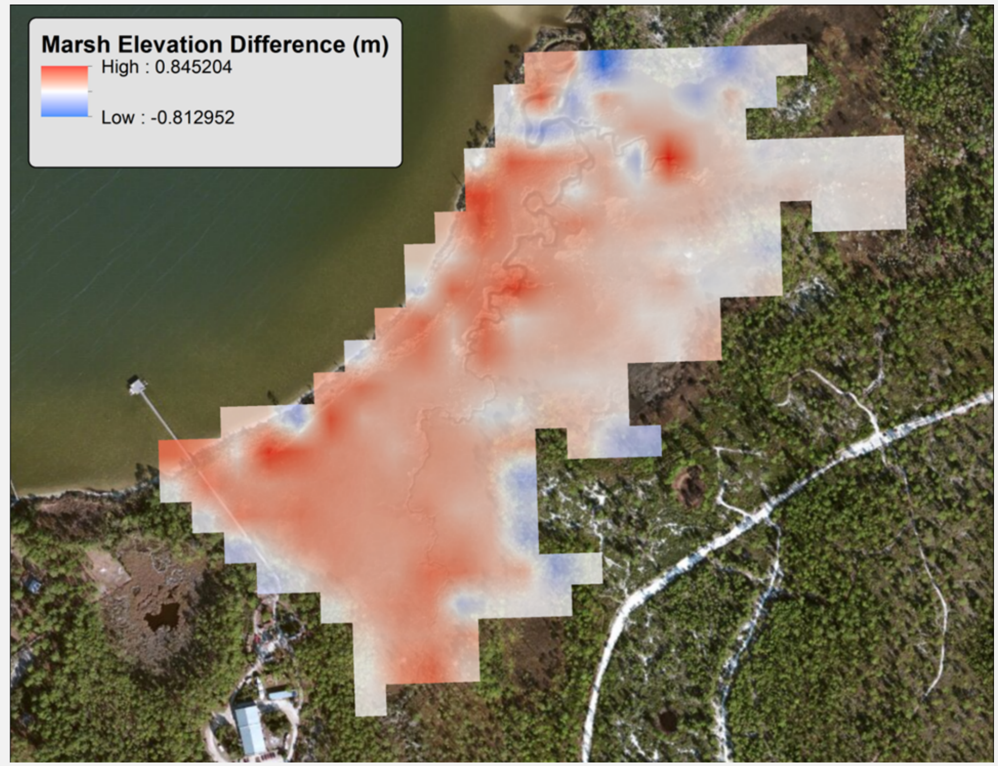
Transdisciplinary research outcomes

Earth's Future Volume 4, Issue 5, pages 194-209, 9 MAY 2016 DOI: 10.1002/2015EF000346



RTK GPS survey vs. lidar DEM at Eastpoint marsh, FL

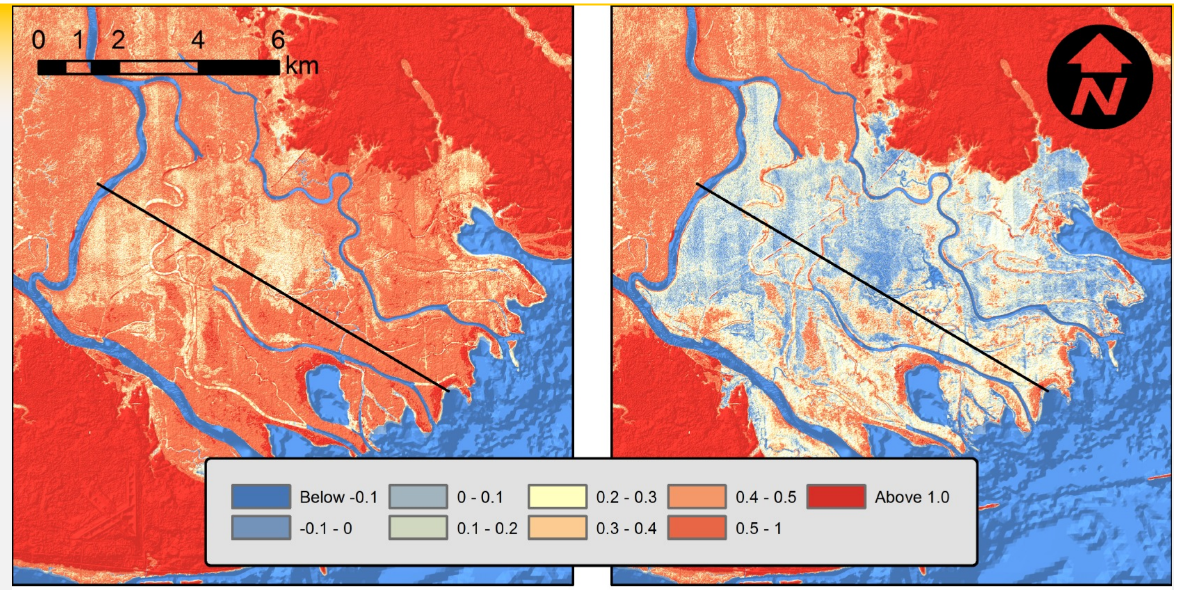


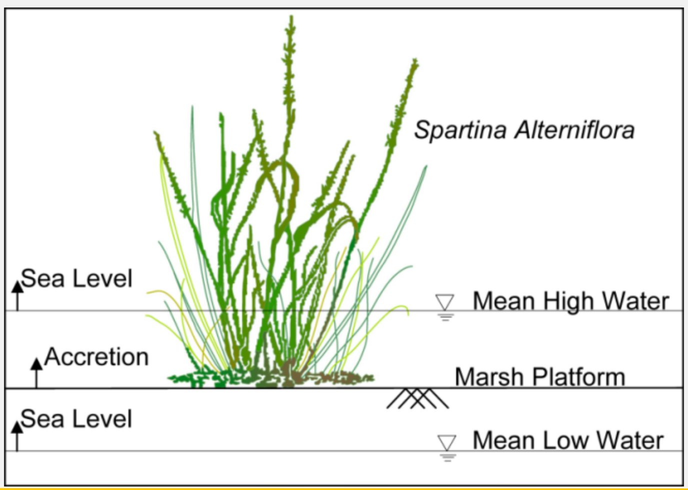


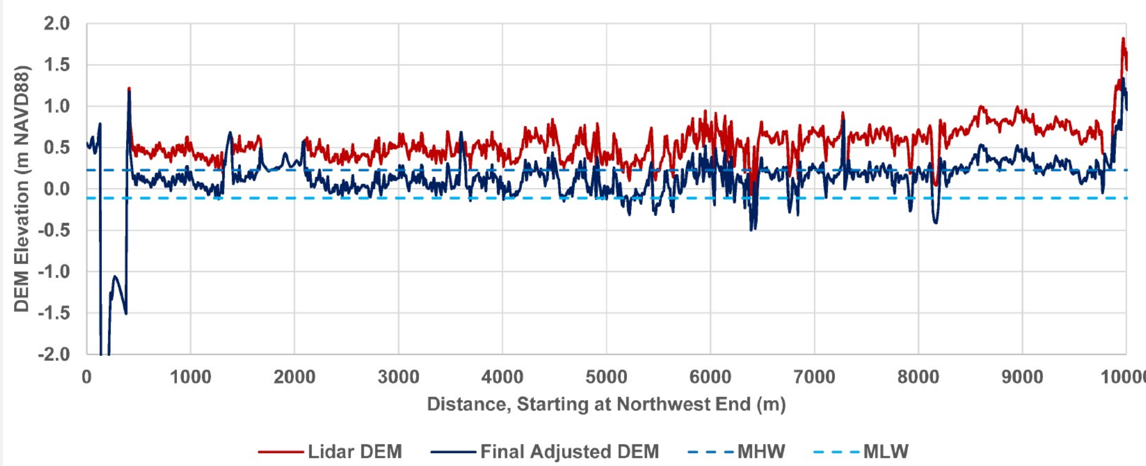
Lidar is not a panacea

- A salt marsh cannot survive unless it's platform is between MHW & MLW.
- If the topographic surface is above MHW it will be upland.
- Below MLW it will be a mud flat or fully immersed.

Kidwell et al. . .*Earth's Future* Volume 5, Issue 1, pages 2-9, 20 JAN 2017 DOI: 10.1002/2016EF000493

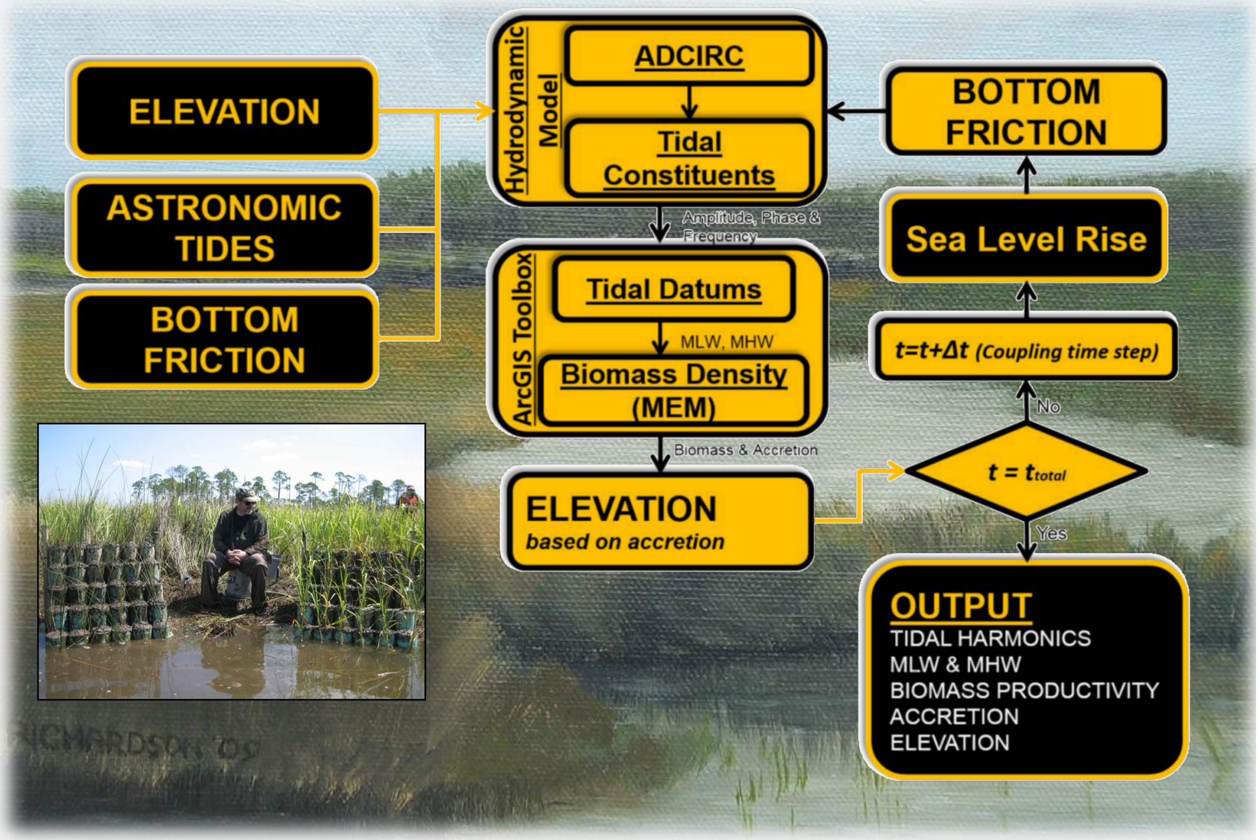






Hydro-MEM: Hydrodynamic-Marsh Equilibrium Model

- Alizad, K., S.C. Hagen, J.T. Morris, S.C. Medeiros, M.V. Bilskie, & J.F. Weishampel, “Coastal wetland response to sea level rise in a fluvial estuarine system.” *Earth’s Future*, Vol. 4(11), pp. 483–497, 2016.
- Alizad, K., S. C. Hagen, Morris, J.T., Bacopoulos, P., Bilskie, M.V., Weishampel, J.F., Medeiros, S.C. (2016). A Coupled, Two-Dimensional Hydrodynamic-Marsh Model with Biological Feedback. *Ecological Modeling, Vol. 327, pp. 29-43.*
- Hagen, S.C., J.T. Morris, P. Bacopoulos, & J. Weishampel. 2013. Sea-Level Rise Impact on a Salt Marsh System of the Lower St. Johns River. *ASCE J. of Waterway, Port, Coastal, and Ocean Engineering, Vol. 139, No. 2, Mar./Apr. 2013, p. 118-125.*

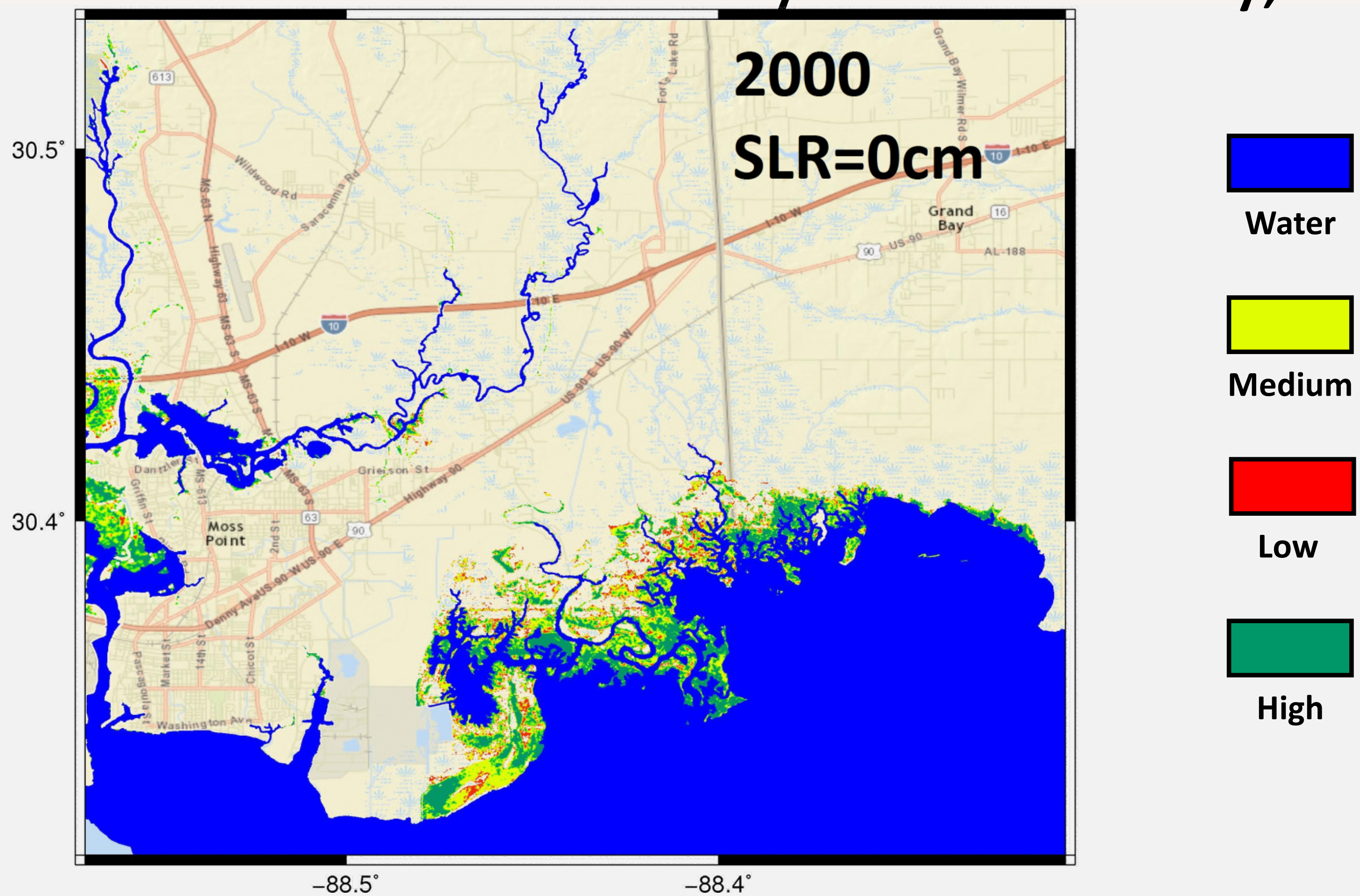


Hydro-MEM: Biomass Productivity in Grand Bay, MS

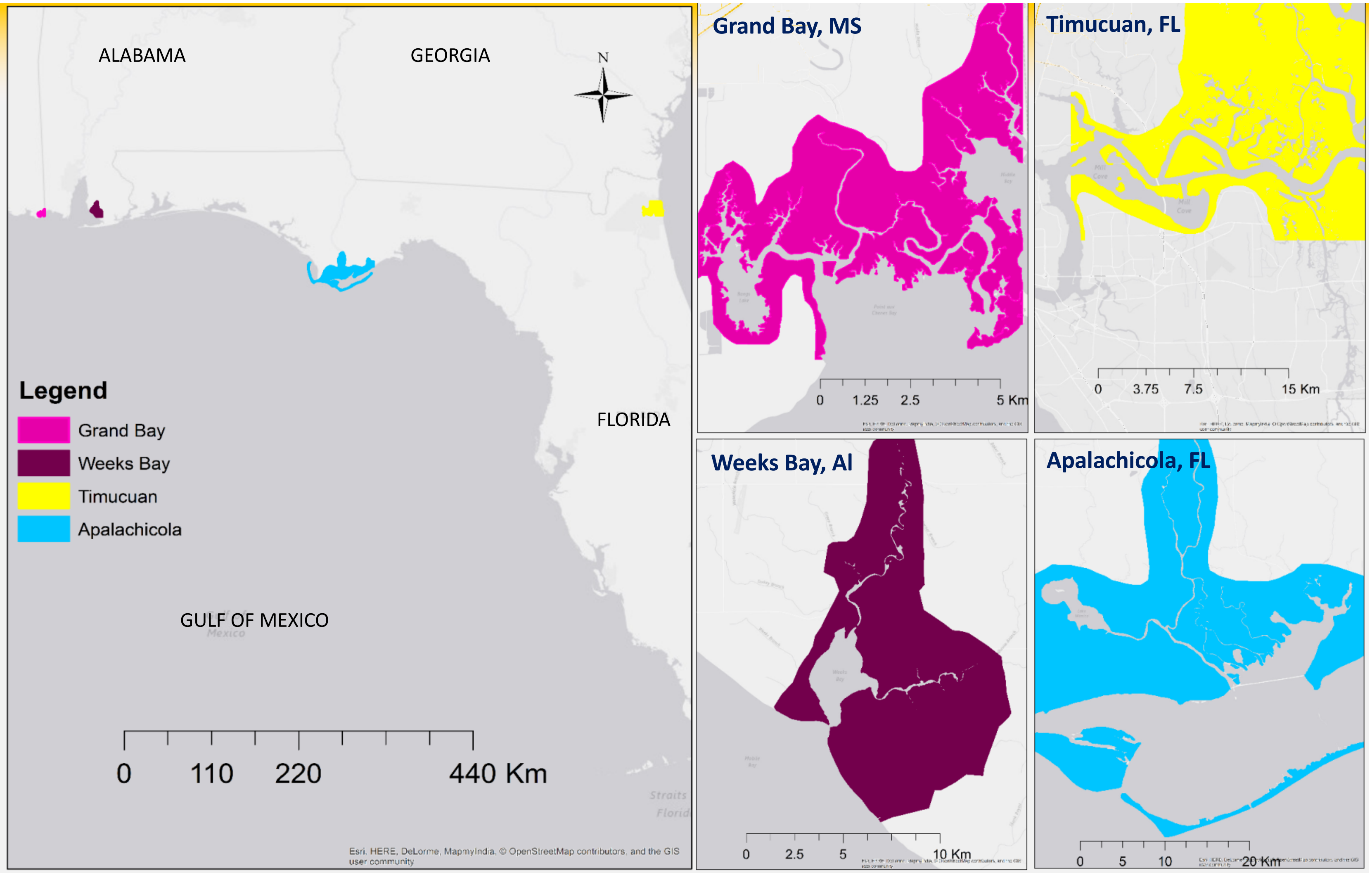
The ADCIRC model is used to simulate astronomic tides with a 1.0 second time step.

Mean high water (MHW) is calculated across the marsh surface.

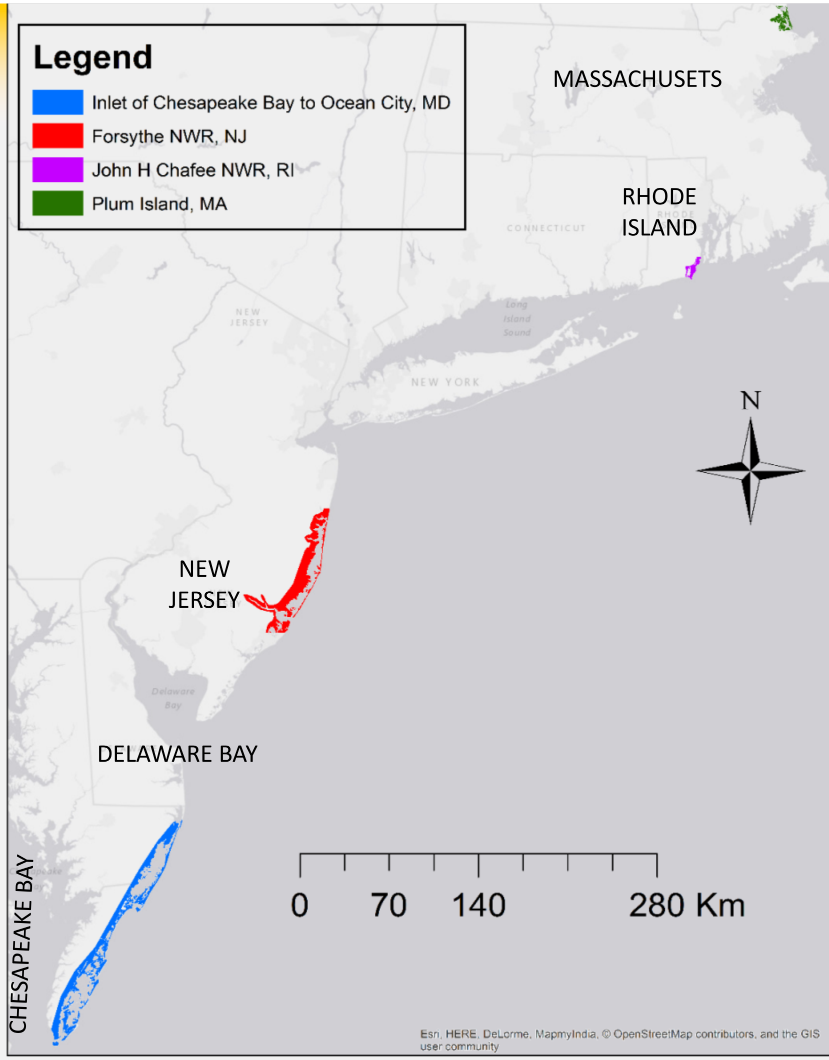
Biomass productivity and accretion is computed on five (5) year intervals and the ADCIRC tidal model is updated to reflect changes in the Digital Elevation Model (DEM) and surface characteristics.

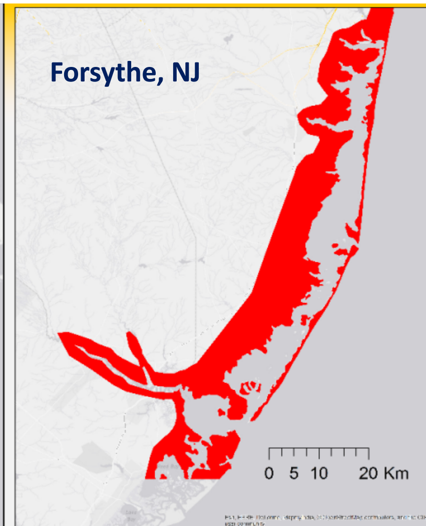


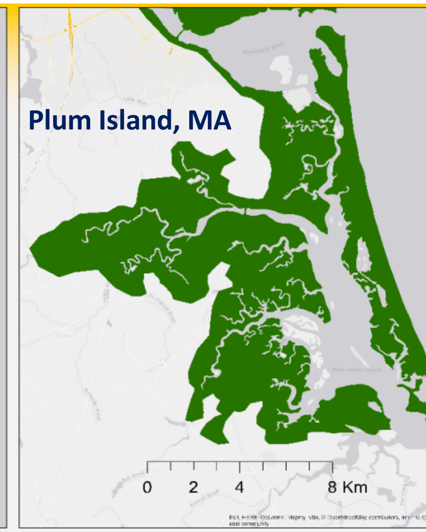
Hydro-MEM Applications

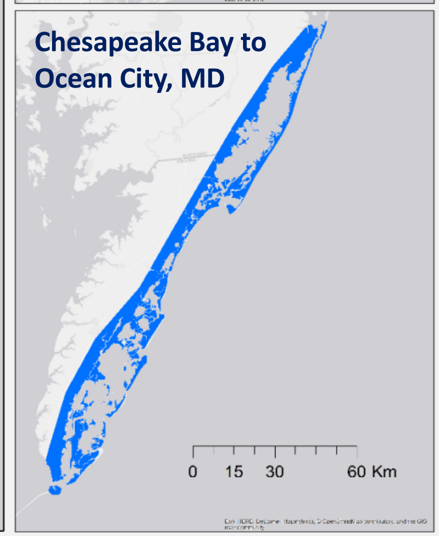


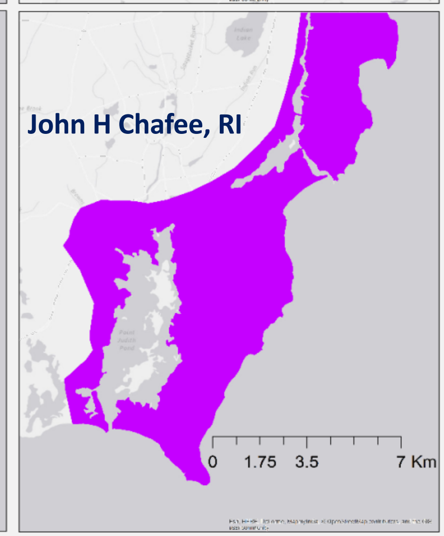
Hydro-MEM Applications





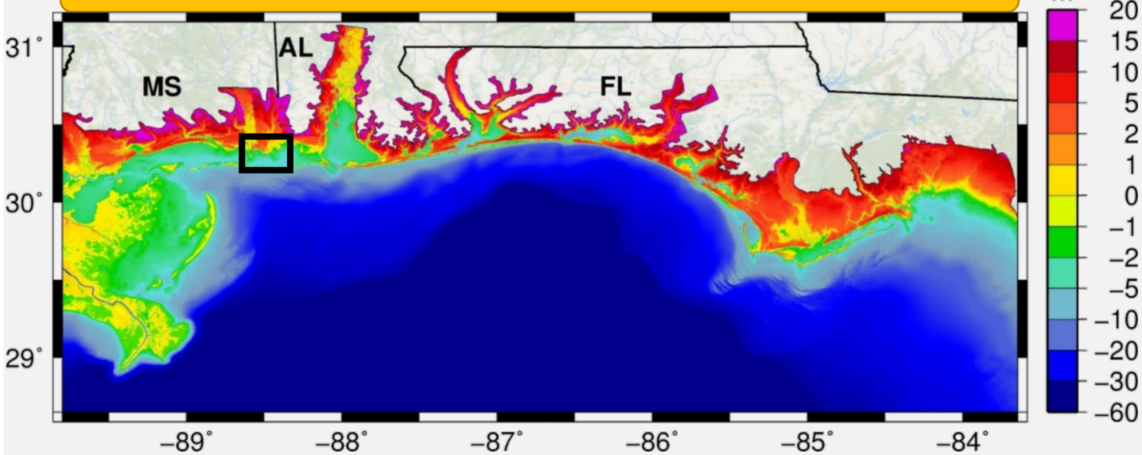


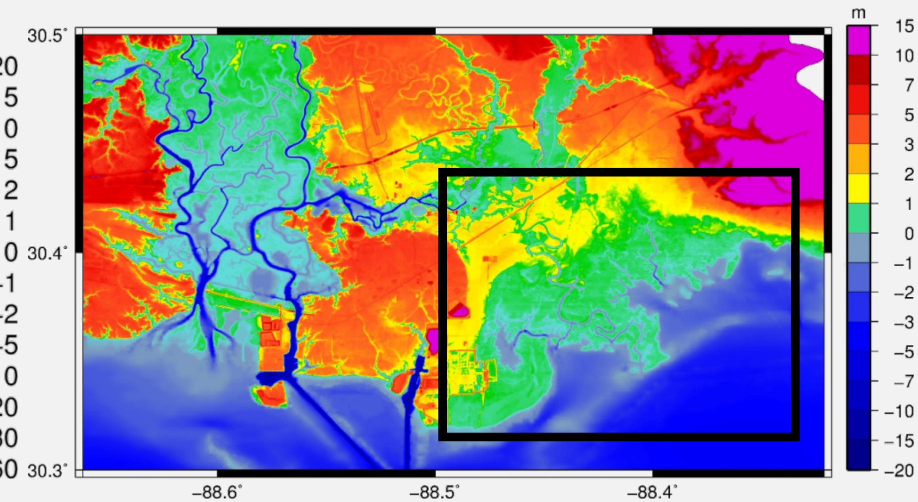


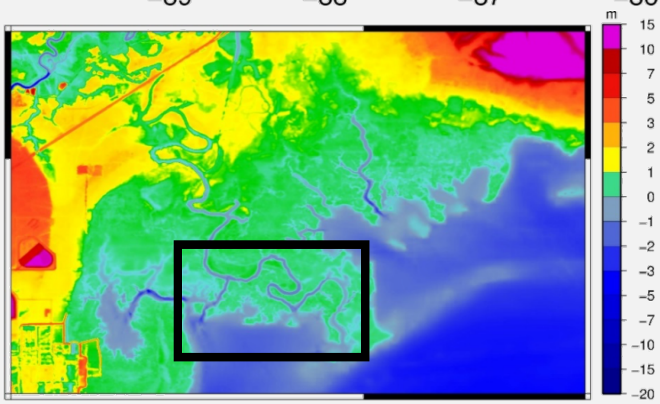


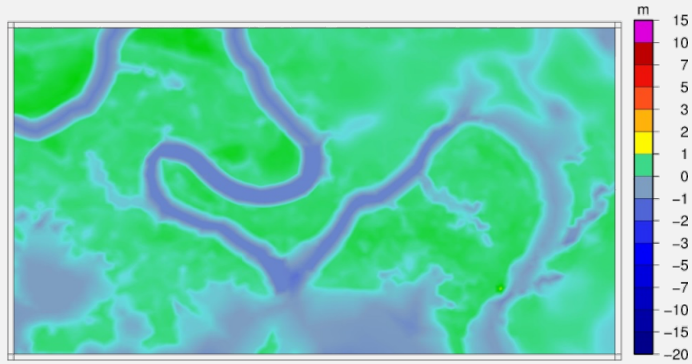
Topographic/bathymetric description of the Grand Bay marsh

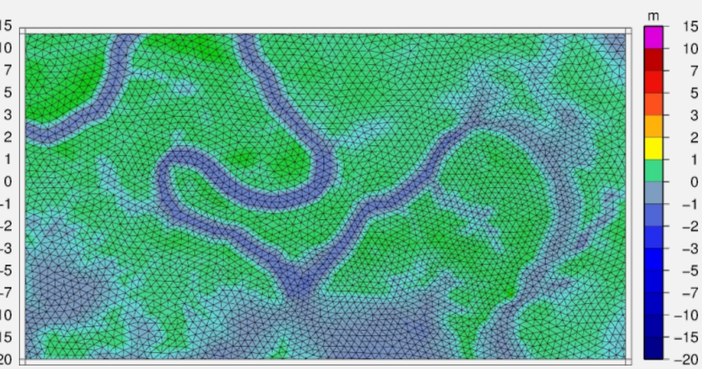
Model topo/bathy for the northern Gulf of Mexico











Bilskie et al., “Data and numerical analysis of astronomic tides, wind-waves, and hurricane storm surge along the northern Gulf of Mexico.” *JGR – Oceans* . Vol. 121(5), pp. 2169-9291. 2016. http://dx.doi.org/10.1002/2015JC011400

ADCIRC+SWAN model framework

WIND FIELD

ASTRONOMIC TIDES

SURFACE ROUGHNESS

ADCIRC MESH

ADCIRC
Finite-element model solves for *long waves*

WAVE STRESSES

WIND SPEEDS
WATER LEVELS
CURRENT VELOCITIES
ROUGHNESS LENGTHS

SWAN
Finite-difference model solves for *short waves*

OUTPUT

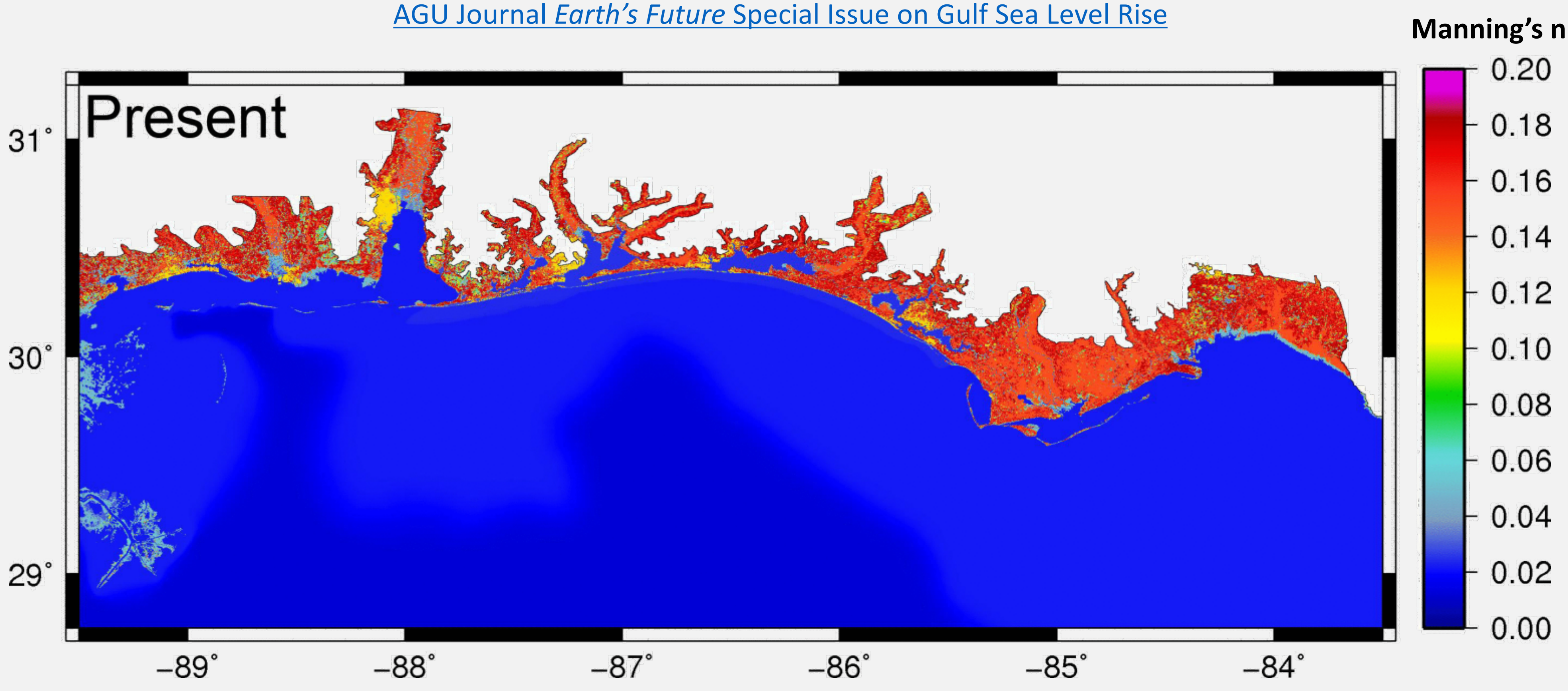
WATER LEVEL
CURRENT VELOCITIES
WAVE RADIATION STRESSES
WIND SPEEDS

PEAK WAVE PERIODS
MEAN WAVE PERIODS
MEAN WAVE DIRECTIONS
SIGNIFICANT WAVE HEIGHTS

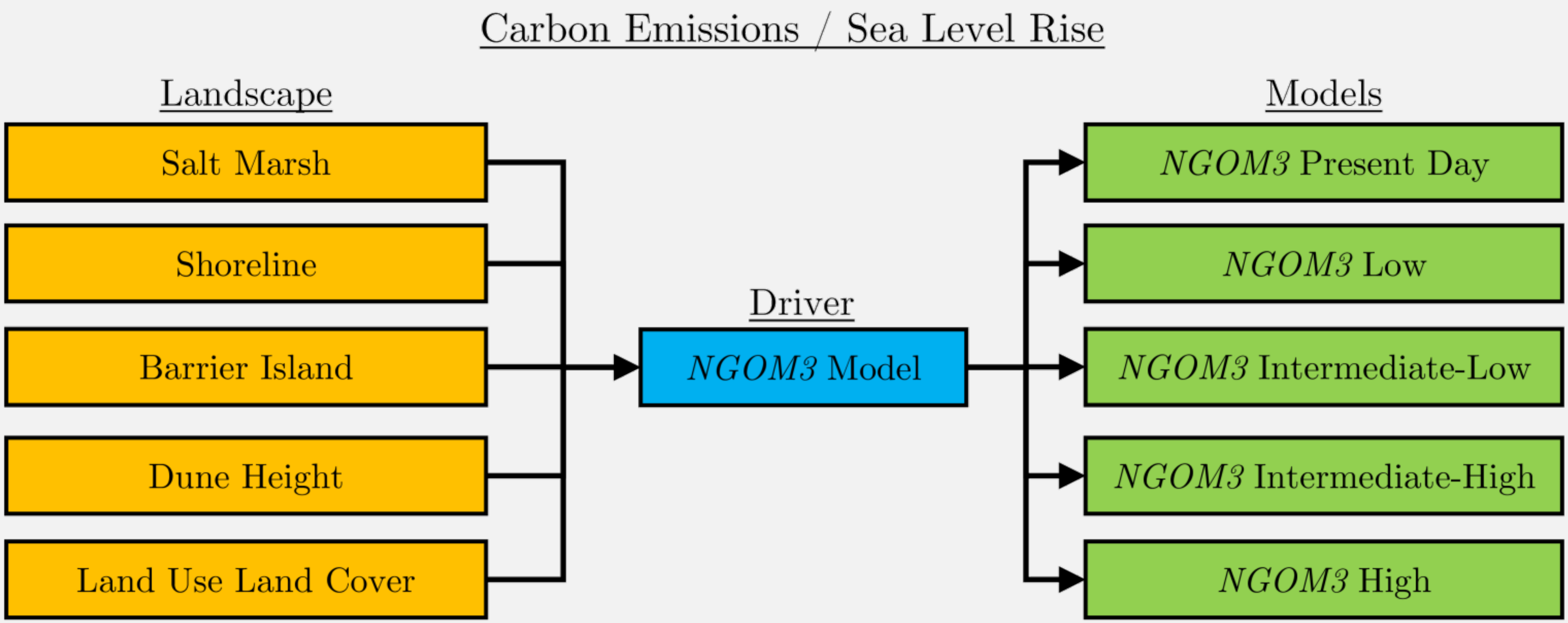
Adapted with permission from: J.C. Dietrich, et al. (2011). Modeling hurricane waves and storm surge using integrally-coupled, scalable computations. *Coastal Engineering*, 58, 45-65

Marshes / LULC / Shoreline & dune morphology

AGU Journal *Earth's Future* Special Issue on Gulf Sea Level Rise



Five Model Configurations

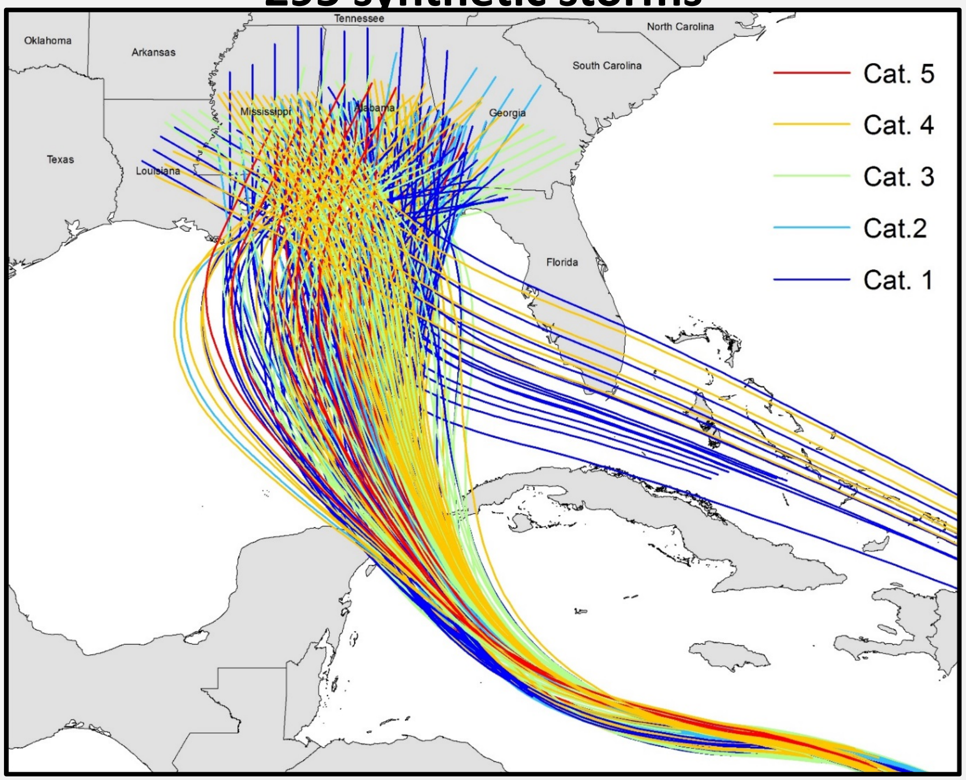


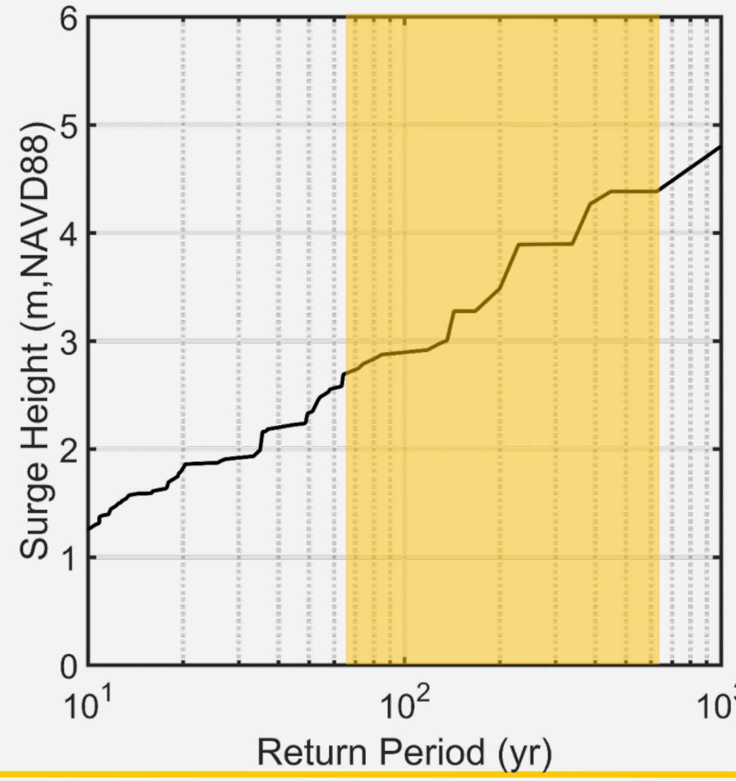
MV Bilskie, et al. (2015). Dynamic simulation and numerical analysis of hurricane storm surge under sea level rise along the northern Gulf of Mexico. *Earth's Future*, http://dx.doi.org/10.1002/2015EF000347

Synthetic Storm Down Selection

Identify a sub-set of synthetic tropical cyclone events that are representative of the 100- and 500-year floodplain.

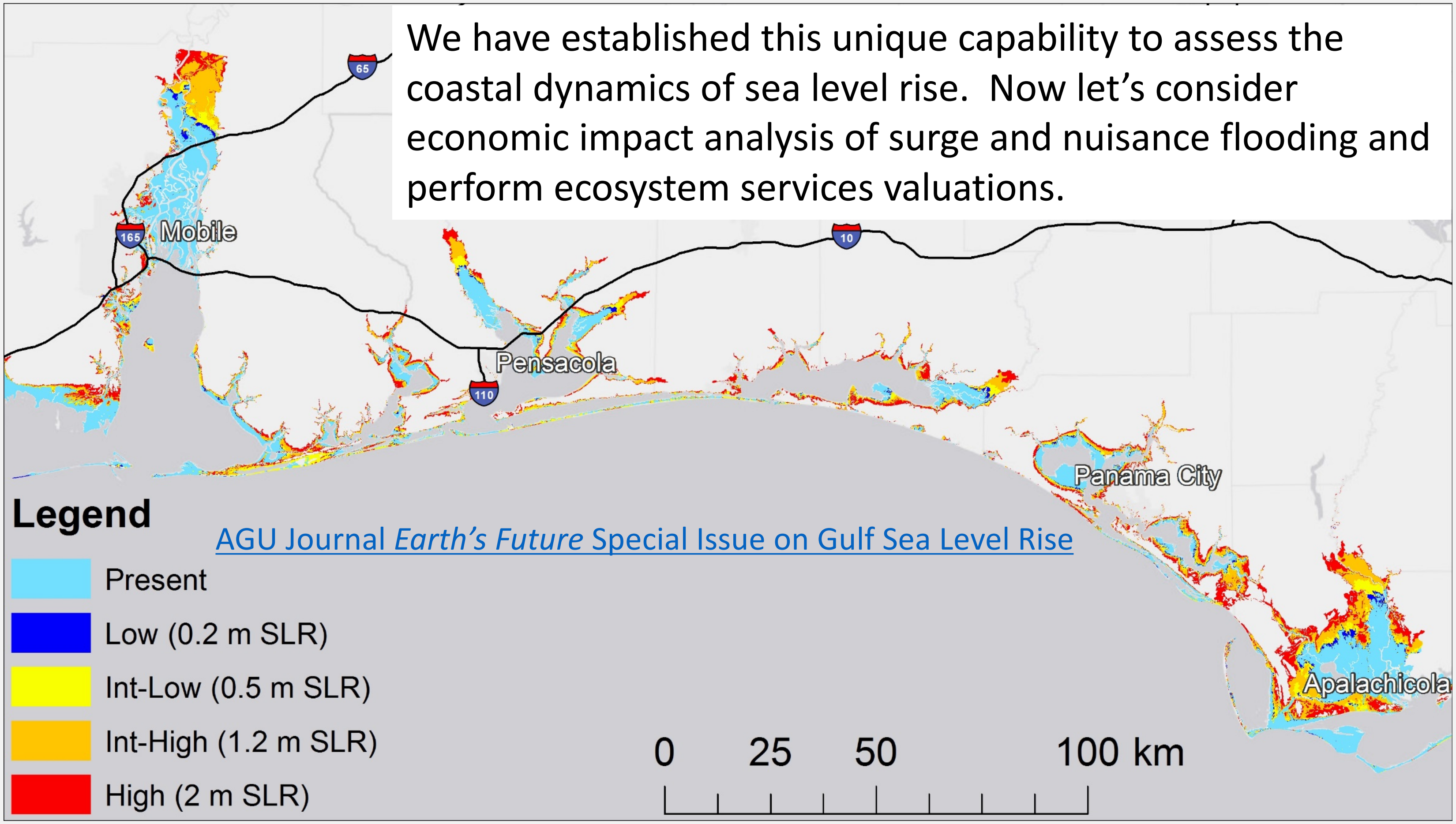
295 synthetic storms





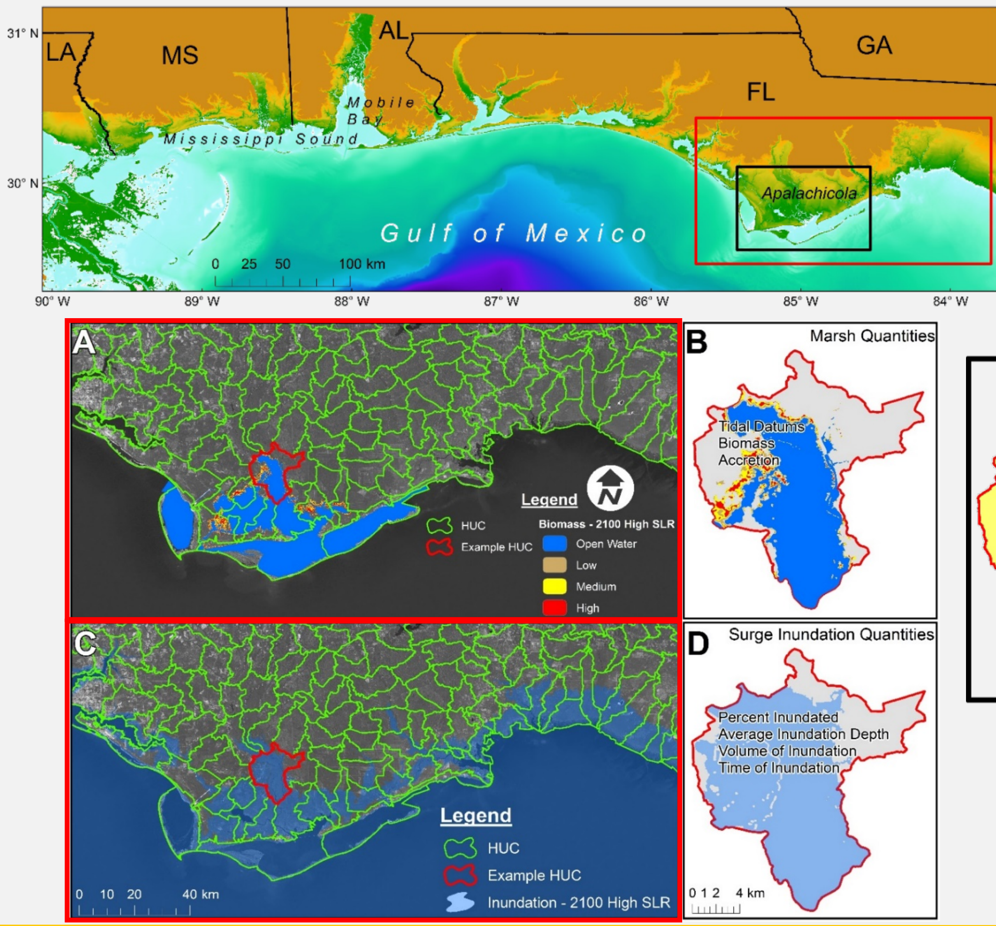
1% probability still-water extents

We have established this unique capability to assess the coastal dynamics of sea level rise. Now let's consider economic impact analysis of surge and nuisance flooding and perform ecosystem services valuations.



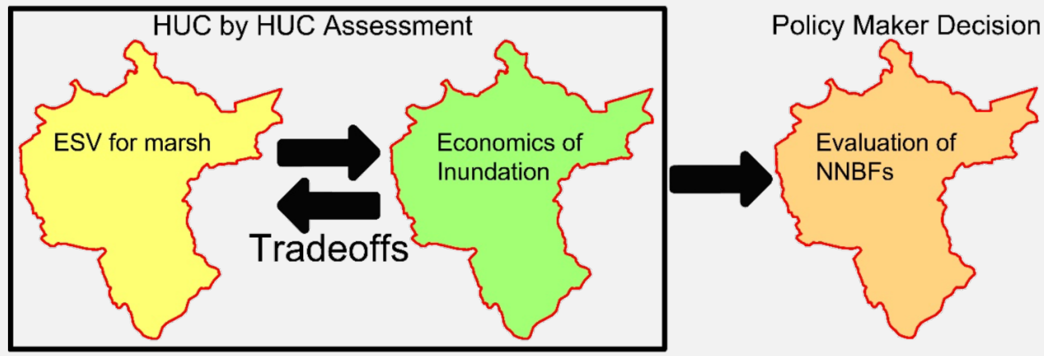
AGU Journal *Earth's Future* Special Issue on Gulf Sea Level Rise

NGOM+N2E2: Dynamic sea level rise assessments of the ability of natural and nature-based features to mitigate surge and nuisance flooding



Given the productivity of a natural feature (e.g., salt marsh), the ecosystem service valuation (ESV) can be performed and from the inundation quantities (e.g., time, depth, area, and volume of surge) an economic loss may be estimated.

The tradeoffs in terms of NNBF value vs. the ability of the NNBF to mitigate inundation can then be assessed. The approach permits an evaluation of NNBFs to aid decision makers and inform the public.



The assessment can be performed by the end-user for a given HU or an assemblage of HUs to inform regional decisions. A streamlined communication of those results, on a HU-by-HU basis, to stakeholders through web-based delivery is an essential benefit.

Concluding remarks

- We no longer have the luxury of stationarity.
- We can now model the dynamic system of systems at amazing scales.
- Hydro-MEM describes the spatial and temporal variation in tides, accretion, biomass, and provides a scientifically-defensible platform upon which we can build more complexities.
- Climate change is a generational problem that we can address, but not will away.
- While our numerical modeling technology is awesome, with respect to climate change the models can only serve as advanced diagnostic tools.

Directly-related publications

1. Kidwell, D., et al., “An Earth's Future Special Collection: Impacts of the coastal dynamics of sea level rise on low gradient coastal landscapes.” *Earth’s Future*, Vol. 5(1), pp. 2–9, 2017. http://dx.doi.org/10.1002/2016EF000493
2. Passeri, D.L. et al. “The dynamic effects of sea level rise on low-gradient coastal landscapes: a review.” *Earth’s Future*, 3, 159–181, 2015. http://dx.doi.org/10.1002/2015EF000298
3. DeLorme, D.E. et al. “Developing and Managing Transdisciplinary and Transformative Research on the Coastal Dynamics of Sea Level Rise: Experiences and Lessons Learned,” *Earth’s Future*, Vol. 4(5), pp. 194-209. 2016. http://dx.doi.org/10.1002/2015EF000346
4. Morris, J.T. et al. “Contributions of organic and inorganic matter to sediment volume and accretion in tidal wetlands at steady state,” *Earth’s Future*, Vol. 4(4), pp. 110-121, 2016. http://dx.doi.org/10.1002/2015EF000334
5. Alizad, K., et al. “Coastal wetland response to sea level rise in a fluvial estuarine system.” *Earth’s Future*, Vol. 4(11), pp. 483–497, 2016. http://dx.doi.org/10.1002/2016EF000385
6. Plant, N.G. et al. “Coupling centennial-scale shoreline change to sea-level rise and coastal morphology in the Gulf of Mexico using a Bayesian network.” *Earth’s Future*, Vol. 4(5), pp. 143-158. 2016. http://dx.doi.org/10.1002/2015EF000331
7. Passeri, D.L. et al. “Tidal Hydrodynamics under Future Sea Level Rise and Coastal Morphology in the Northern Gulf of Mexico.” *Earth’s Future*, Vol. 4(5), pp. 159-176. 2016. http://dx.doi.org/10.1002/2015EF000332
8. Bilskie, M.V. et al. "Dynamic simulation and numerical analysis of hurricane storm surge under sea level rise with geomorphologic changes along the northern Gulf of Mexico." *Earth’s Future*, Vol. 4(5), pp. 177-193. 2016. http://dx.doi.org/10.1002/2015EF000347
9. Hovenga, P.A. et al. "The response of runoff and sediment loading in the Apalachicola River, Florida to climate and land use land cover change." *Earth’s Future*, Vol. 4(5), pp. 124-142. 2016. http://dx.doi.org/10.1002/2015EF000348
10. Huang, W., et al. “Suspended sediment projections in Apalachicola Bay in response to altered river flow and sediment loads under climate change and sea level rise.” *Earth’s Future*, Vol. 4(10), pp. 428–439, 2016. http://dx.doi.org/10.1002/2016EF000384
11. Alizad, K., et al., “A coupled, two-dimensional hydrodynamic-marsh model with biological feedback.” *Ecological Modelling*, Vol. 327, pp. 29-43, 2016. http://dx.doi.org/10.1016/j.ecolmodel.2016.01.013
12. Bilskie*, M.V., **S.C. Hagen,** S.C. Medeiros, A.T. Cox, M. Salisbury, D. Coggin, "Data and numerical analysis of astronomic tides, wind-waves, and hurricane storm surge along the northern Gulf of Mexico." *J. Geophys. Res. Oceans,* Vol. 121(5), pp. 2169-9291. 2016. http://dx.doi.org/10.1002/2015JC011400
13. Passeri, D.L., et al., “Impacts of historic morphology and sea level rise on tidal hydrodynamics in a microtidal estuary (Grand Bay, Mississippi).” *Continental Shelf Research*, Vol. 111, pp. 150-158, 2015. http://dx.doi.org/10.1016/j.csr.2015.08.001
14. Passeri, D.L., et al., “On the significance of incorporating shoreline changes for evaluating coastal hydrodynamics under sea level rise scenarios.” *Nat. Hazards*, Vol. 75 (2), 2015, pp. 1599-1617. http://dx.doi.org/10.1007/s11069-014-1386-y
15. Huang, W., et al., “Hydrodynamic modeling and analysis of sea-level rise impacts on salinity for oyster growth in Apalachicola Bay, Florida.” *Estuarine, Coastal and Shelf Science*, Vol. 156, pp. 7-18. 2014. http://dx.doi.org/10.1016/j.ecss.2014.11.008
16. Bilskie, M.V., et al., “Dynamics of sea level rise and coastal flooding on a changing landscape.” *Geophysical Research Letters*, Vol. 41, 2014, pp. 1-8. http://dx.doi.org/10.1002/2013GL058759.
17. Hagen, S.C., J.L. Irish, “Implications, Planning, and Design Considerations for Rising Sea Levels at the Coast.” ASCE *Journal of Waterway, Port, Coastal, and Ocean Engineering*, Vol. 139, No. 2, March/April 2013, p. 81. http://ascelibrary.org/doi/abs/10.1061/(ASCE)WW.1943-5460.0000186
18. Wang, D., et al., “Climate Change Impact and Uncertainty Analysis of Extreme Rainfall Events in the Apalachicola River Basin, Florida.” *Journal of Hydrology*, Vol. 480, 2013, pp. 125-135. http://dx.doi.org/10.1016/j.jhydrol.2012.12.015.
19. Hagen, S.C., P. Bacopoulos*, “Synthetic Storms Contributing to Coastal Flooding in Florida’s Big Bend Region with Application to Sea Level Rise Impact.” *Terrestrial, Atmospheric and Oceanic Sciences*, Vol. 23, No. 5, October 2012, pp. 481-500. http://dx.doi.org/10.3319/TAO.2012.04.17.01(WMH)
20. Hagen, S.C., M.V. Bilskie, D.L. Passeri, D.E. DeLorme, D. Yoskowitz, “Systems Approaches for Coastal Hazard Assessment and Resilience.” Oxford Research Encyclopedia: Natural Hazard Science. Edited by Susan Cutter. In press.

Acknowledgments

Note: The views expressed herein are the presenter's (shagen@lsu.edu) and do not necessarily reflect the opinions of his co-authors or: