Mississippi River Delta Management Study: AdH/SEDLIB Modeling Components

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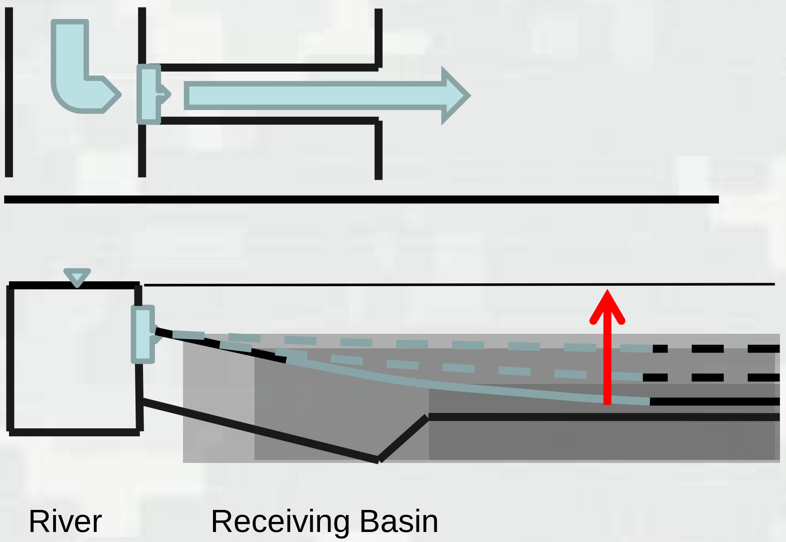
Introduction

- In order to evaluate the potential impacts and benefits of sediment diversions, dedicated dredging, marsh creation, and other potential alternatives for mitigating land loss in Coastal Louisiana, it is necessary to develop a modeling framework that is capable of simulating the processes that govern the interactions between these features, the Lower Mississippi River, and the existing coastal wetlands and receiving waters.
- It is recognized that quantity and complexity of these processes are beyond the capacity for any modeling system to simulate from first principles. The need for simplification, parameterization, and quantification of uncertainty are all necessary aspects of the modeling process.

Introduction

The AdH/SEDLIB model application developed for the Mississippi River Hydrodynamic and Delta Management Study is designed to address several of the fundamental processes that govern these interactions. These are as follows:

- River hydrodynamics
- Riverine sediment transport and morphologic change
- Estuarine hydrodynamics
- Estuarine sediment transport and morphologic change
- Wetland dynamics (including vegetation growth and mortality)
- Relative sea level rise
- Salinity



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AdH-Adaptive Hydraulics

AdH is the Adaptive Hydraulics model, a finite element numerical model applied in 2-D depth averaged mode.

- Finite element model
- Implicit solution scheme
- The adaptive aspect of AdH is its ability to dynamically refine the domain mesh in areas where more resolution is needed at certain times due to changes in the flow and/or transport conditions.
- time step cutting based on convergence criteria
- AdH has been used widely in investigate both riverine and estuarine issues
- For more information on AdH, please visit the website:
  - http://adh.usace.army.mil/new_webpage/main/main_page.htm

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SEDLIB

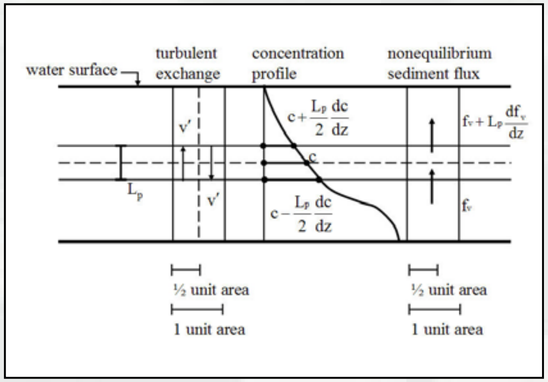
SEDLIB is a sediment transport library

- multi-grain class sediment transport
- cohesive and noncohesive sediment
- bedload and suspended load
- Multiple bed layers (for storing strata)
- Based on CH3D fundamental logic (Brown, 2012)
- SEDLIB documentation can be found on the AdH website.

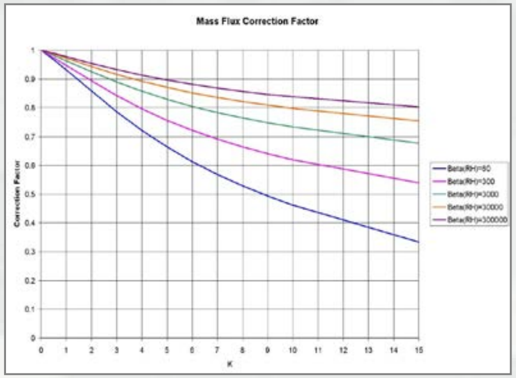
Brown, G.L. (2012) “Modification of the Bed Sediment Equations of Spasojevic and Holly (1993) to Account for Variable Porosity, Variable Grain Specific Gravity, and Nonerodable Boundaries” IIHR Third International Symposium on Shallow Flows, Iowa City, IA, June 4-6 2012.

SEDLIB Quasi 3D Capability

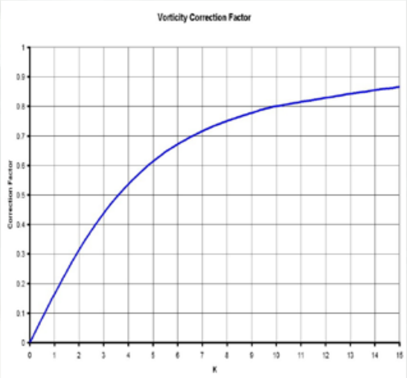
SEDLIB is equipped with methods to approximate 3D sediment behavior, to permit modeling of sediment processes in rivers for many commonly observed conditions.



Nonequilibrium sediment profile



Horizontal mass flux correction



Bendway mass flux correction

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Brown, G.L. (2012) “A Quasi-3D Suspended Sediment Model Using a Set of Correction Factors Applied to a Depth Averaged Advection Diffusion Equation” IIHR Third International Symposium on Shallow Flows, Iowa City, IA, June 4-6 2012.

Brown, G.L. (2008) “Approximate Profile for Nonequilibrium Suspended Sediment” J. Hydr. Engrg. 134, 1010 (2008), DOI:10.1061/(ASCE)0733-9429(2008)134:7(1010

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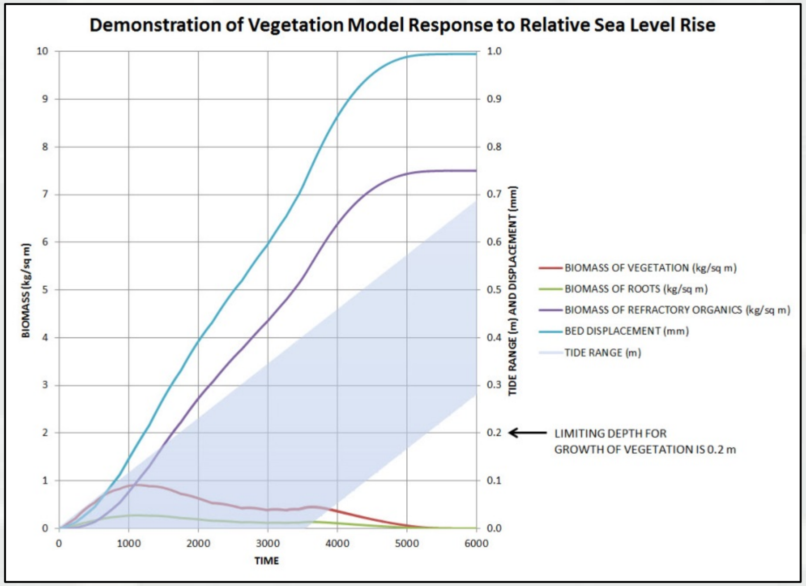
Wetland Vegetation Model

- Based heavily on Fagherazzi et al (2012)
- Vegetation growth as a function of depth, with max growth at depth = 0. and zero growth at depth equal limiting depth
- Roots are in constant ratio to plants ("root to shoot" ratio)
- Decaying roots and shoots, are stored as refractory sediment (with some specified labile fraction removed)
- Roots have very low bulk density, which "swells" the surface, and collapses the surface when marshes drown.



Fagherazzi, S., et al. (2012), Numerical models of salt marsh evolution: Ecological, geomorphic, and climatic factors, Rev. Geophys., 50, RG1002, doi:10.1029/2011RG000359.

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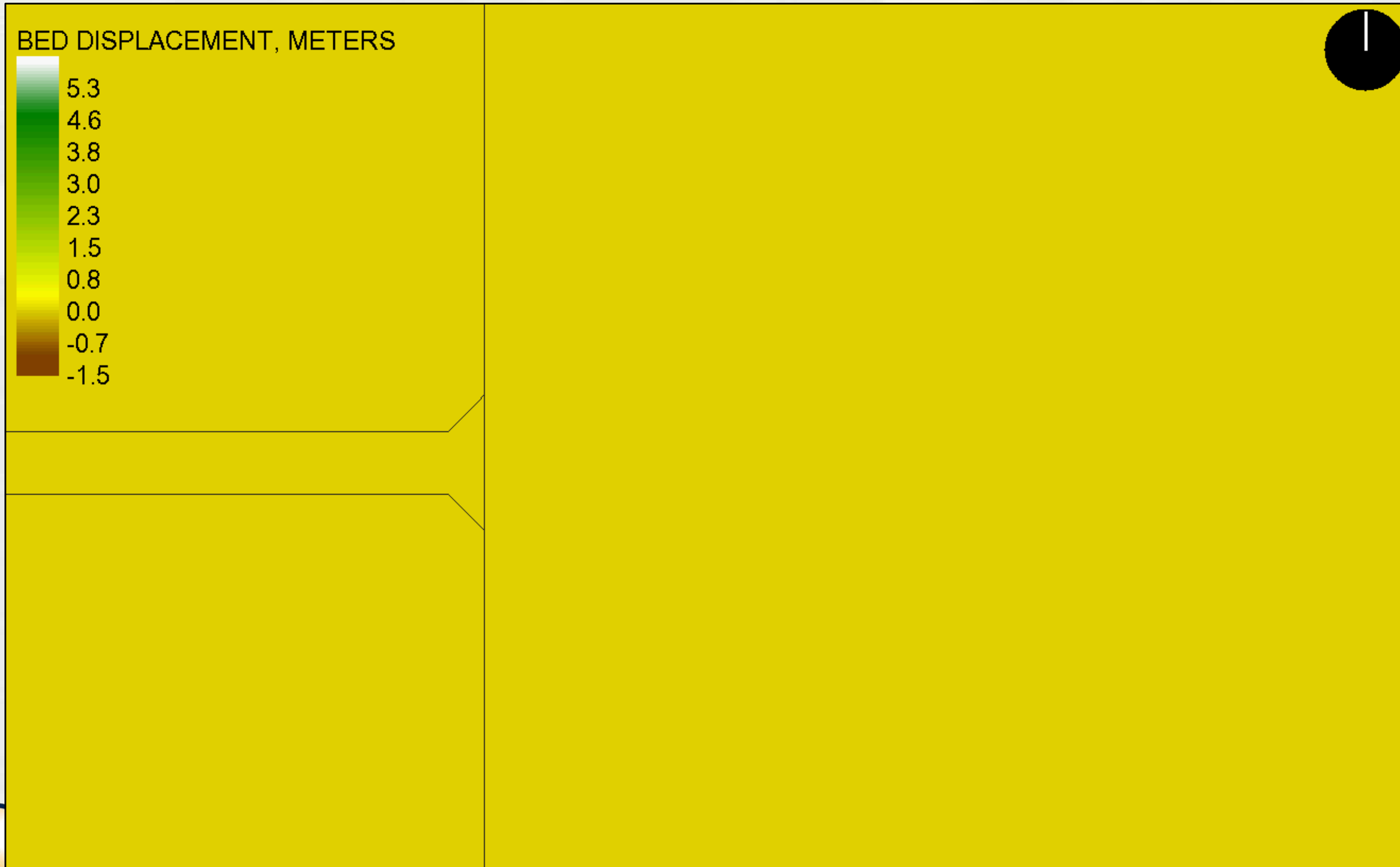
Coastal Louisiana Morphologic Model Parameters

Parameter	Value	Primary Source
Maximum above ground primary productivity (kg/sq m/s)	2.65E-06	(Kirwen and Guntenspergen, 2012)
Limiting water depth for plant growth (m)	0.2	(Kirwen and Guntenspergen, 2012)
Root to shoot ratio	0.3	(Kirwen and Guntenspergen, 2012)
maximum depth of root penetration (m)	1.5	(Meselhe, 2015)
labile fraction	0.1	(various sources)
Maximum equilibrium vegetation mass (kg/sq m)	1.6	(Kirwen and Guntenspergen, 2012)
specific gravity of organics	1.5	(various sources)
wet bulk density of roots (kg/cu m)	1045.3	(boudreaux)
wet bulk density of refractory organics (kg/cm m)	1200	(Meselhe, 2015)

Kirwan , Matthew L. Kirwan and Guntenspergen, Glenn R. (2012) *Feedbacks between inundation, root production, and shoot growth in a rapidly submerging brackish marsh* Journal of Ecology 2012, 100, 764–770
doi: 10.1111/j.1365-2745.2012.01957.x

GRAIN CLASS	DIAMETER, mm	SETTLING VELOCITY mm/sec	CRITICAL SHEAR FOR EROSION, Pa	EROSION RATE CONSTANT, kg/m2-sec	CRITICAL SHEAR FOR DEPOSITION, Pa
CLAY	0.003	0.009	0.5	0.01	0.005
VFM	0.006	0.036	0.5	0.01	0.01
FM	0.011	0.121	0.5	0.01	0.02
MM	0.023	0.529	0.5	0.01	0.04
CM	0.045	2.025	0.5	0.01	0.075

Example of Wetland Modeling



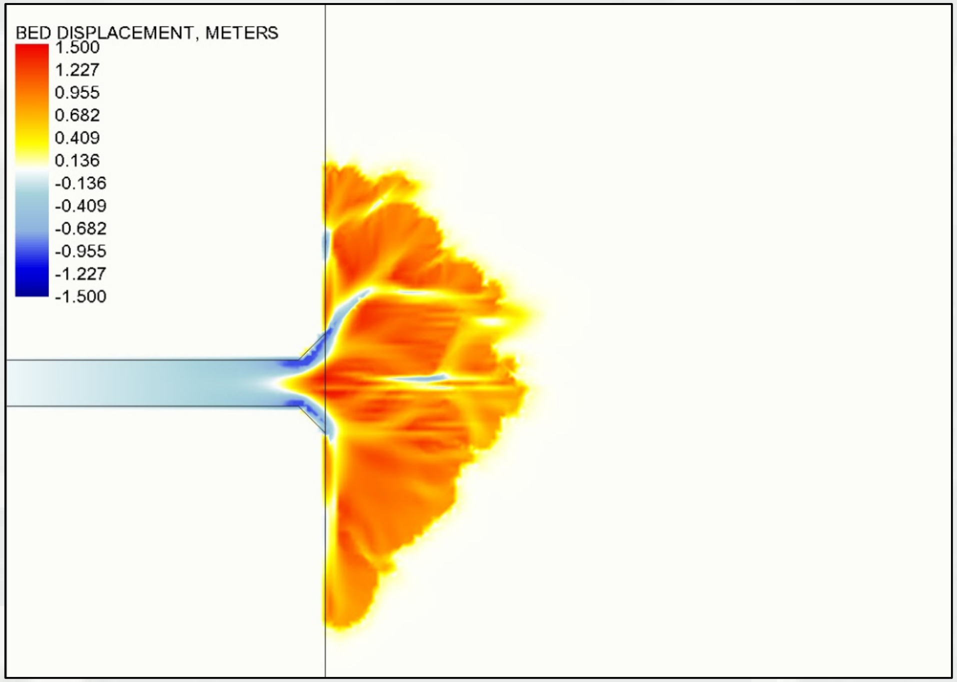
Morphologic Acceleration with Porosity Factor

In order to investigate the long term (multi-decadal) effects of sediment diversions, it is necessary to develop a means whereby morphologic change can be “accelerated” within the model.

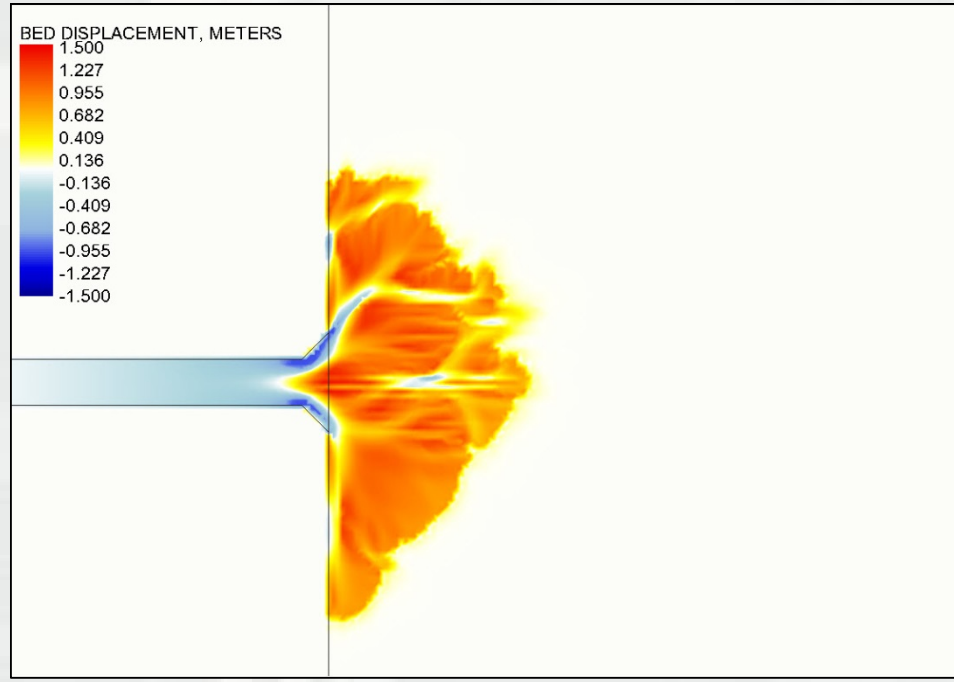
For quasi-steady conditions (i.e. slowly-varying conditions) a simple and straightforward method of estimating this acceleration is to scale the porosity of the sediment

$$p_\beta = 1 - \frac{1}{\beta}(1 - p)$$

Testing Morphologic Change with Porosity Factor: 180 Days



Porosity Factor = 1.0: T=180 days



Porosity Factor = 10.0:T = 18 days

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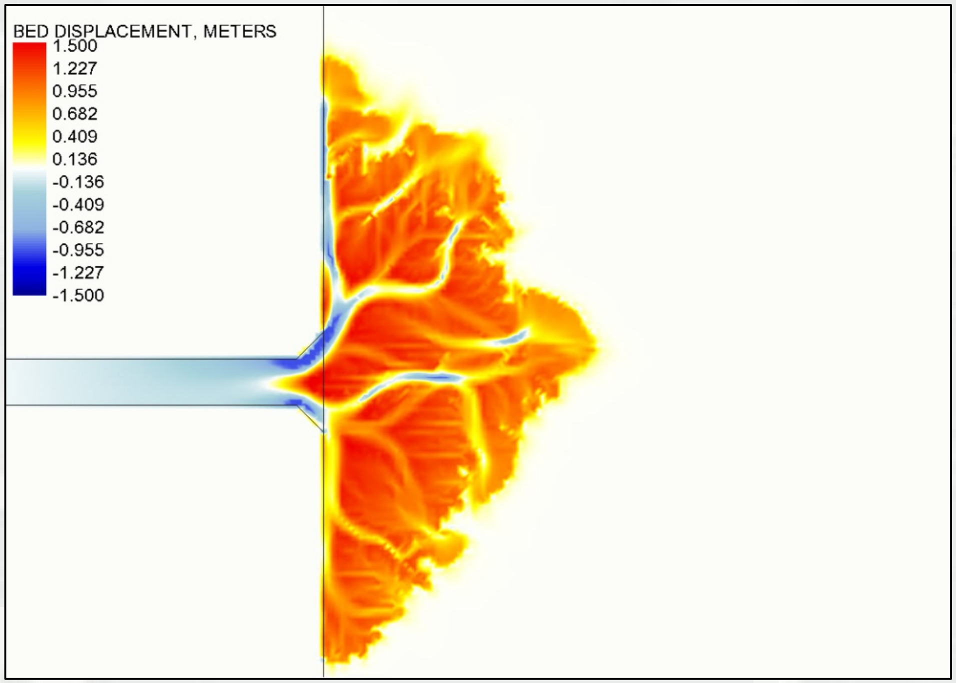
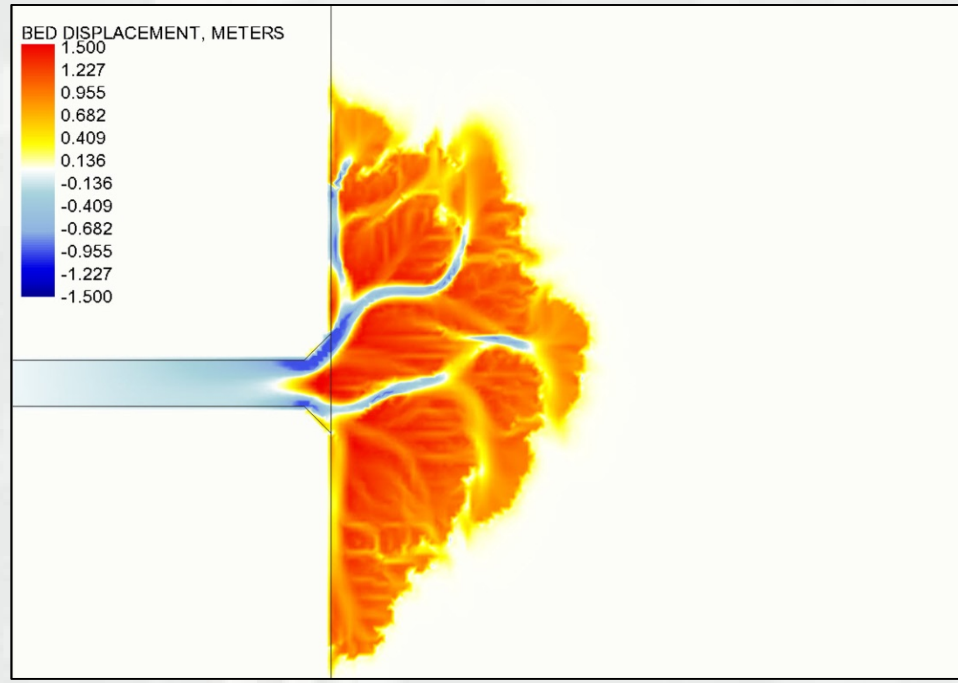
Testing Morphologic Change with Porosity Factor: 360 Days



Porosity Factor = 1.0: T = 360 days



Porosity Factor = 10.0: T = 36 days

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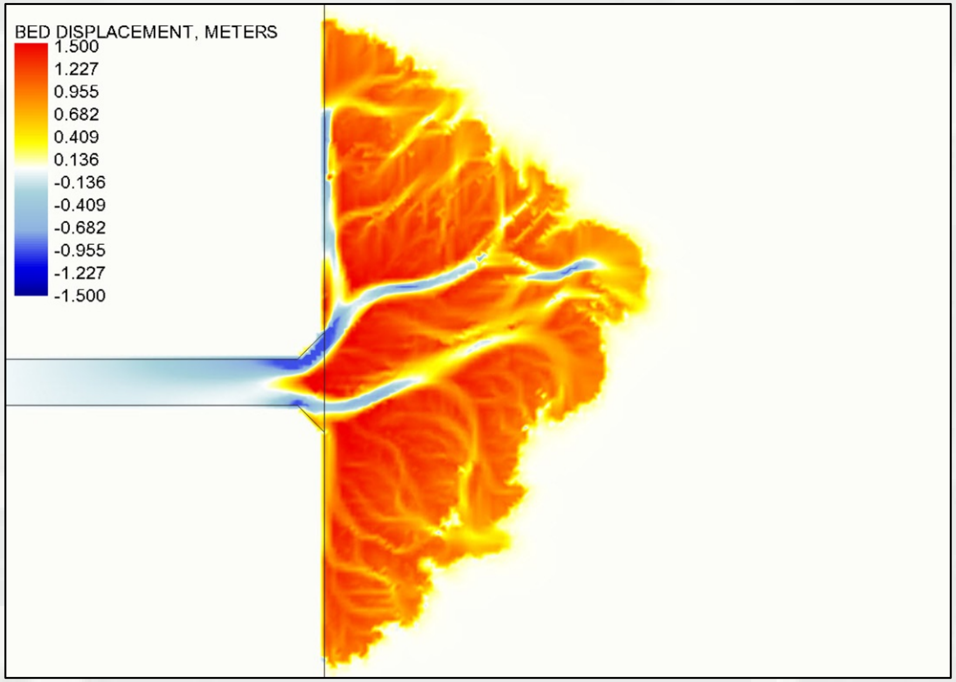
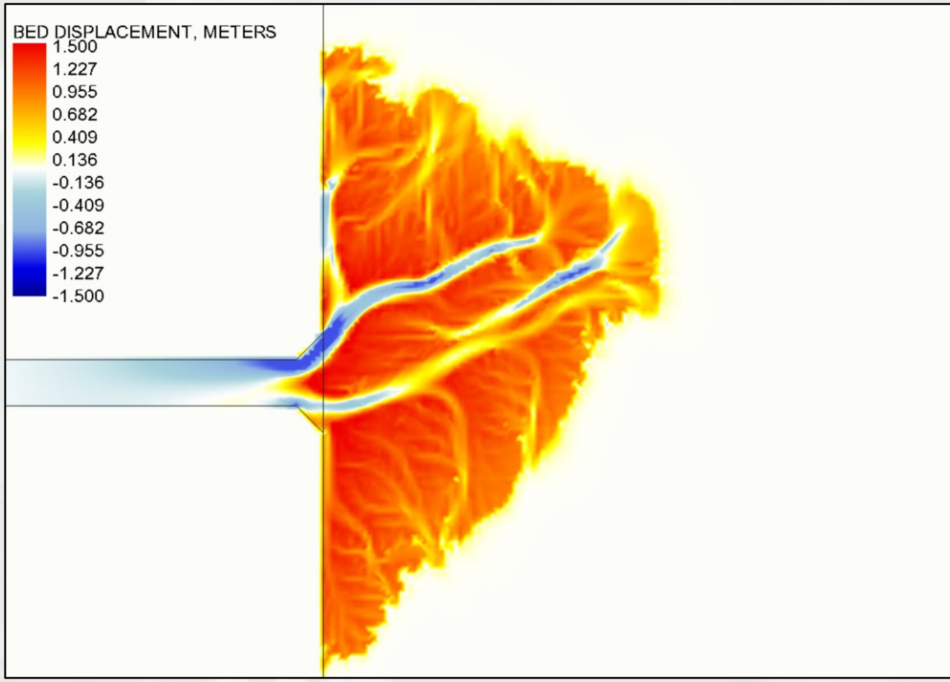
Testing Morphologic Change with Porosity Factor: 540 Days



Porosity Factor = 1.0: T = 540 days



Porosity Factor = 10.0: T = 54 days

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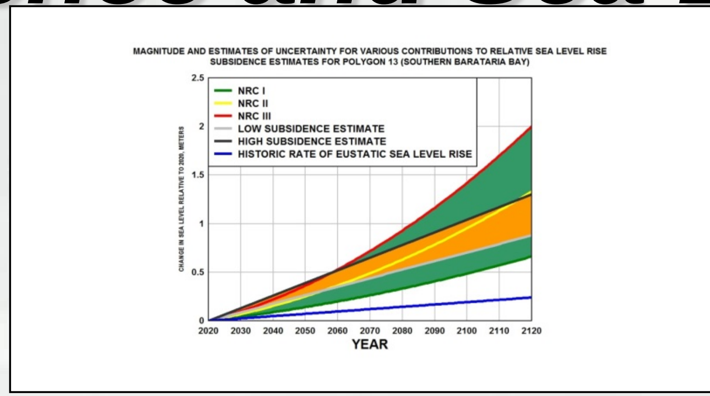
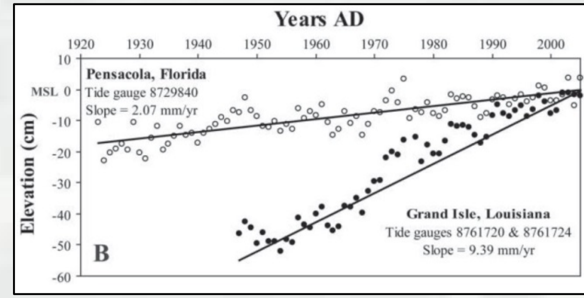
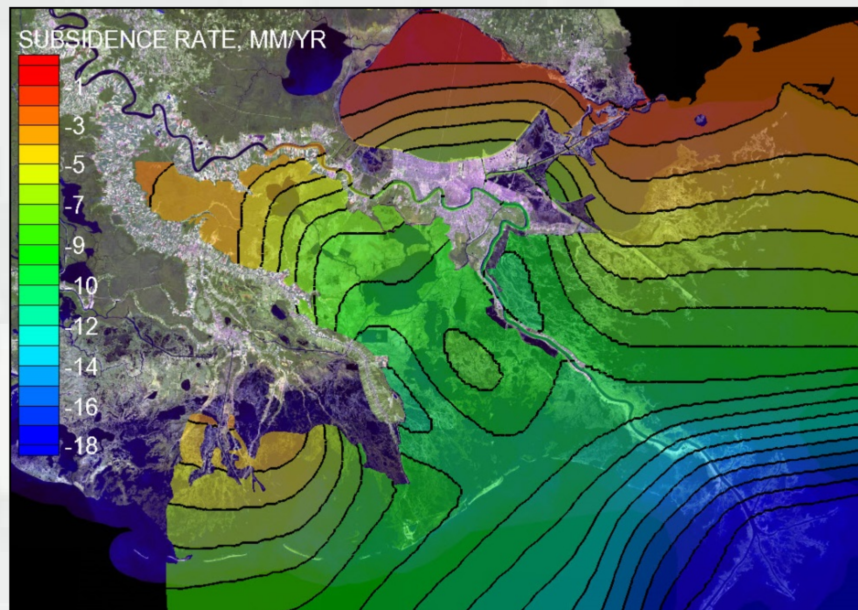
Subsidence and Sea Level Rise





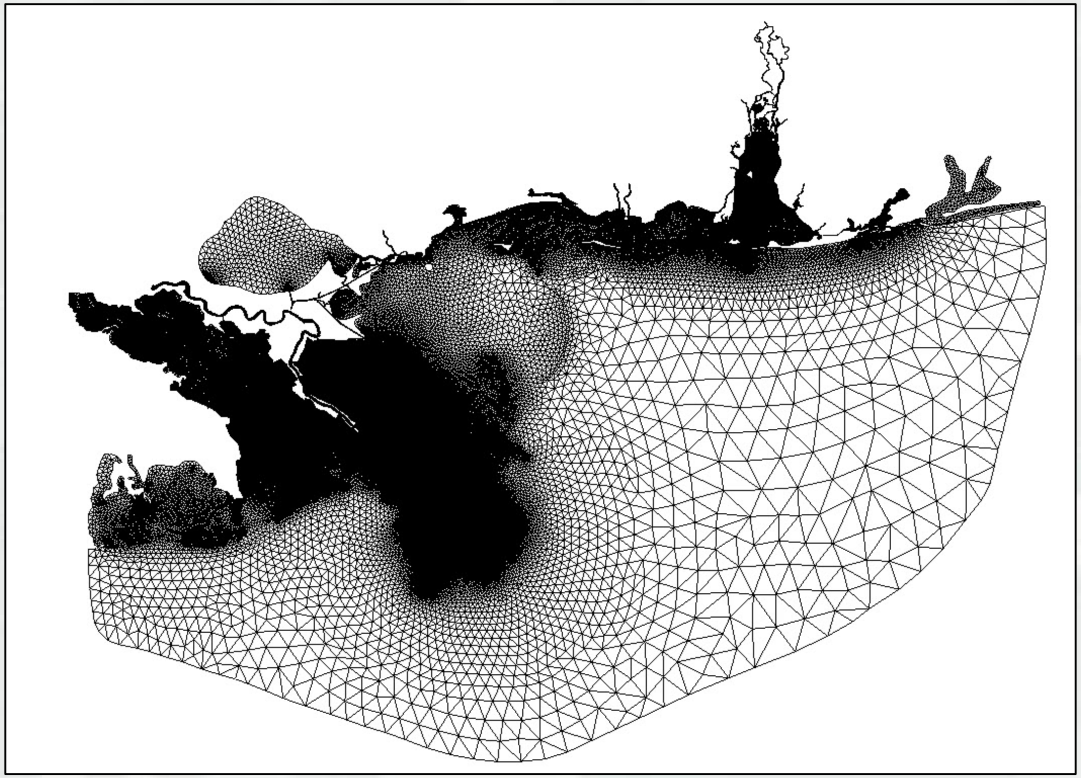
We are addressing Relative Sea Level Rise (Sea Level Rise plus subsidence) by addressing both spatial variability and uncertainty.



Joint approach agreed upon by the State of Louisiana and the USACE.

AdH Domain

- Includes Mississippi River, Pontchartrain, Breton Sound, Barataria Bay, and the Northwest Gulf of Mexico.
- 377408 Nodes, 739319 Elements
- Finest resolution ~10 meters.
- Adaption adds resolution where needed.



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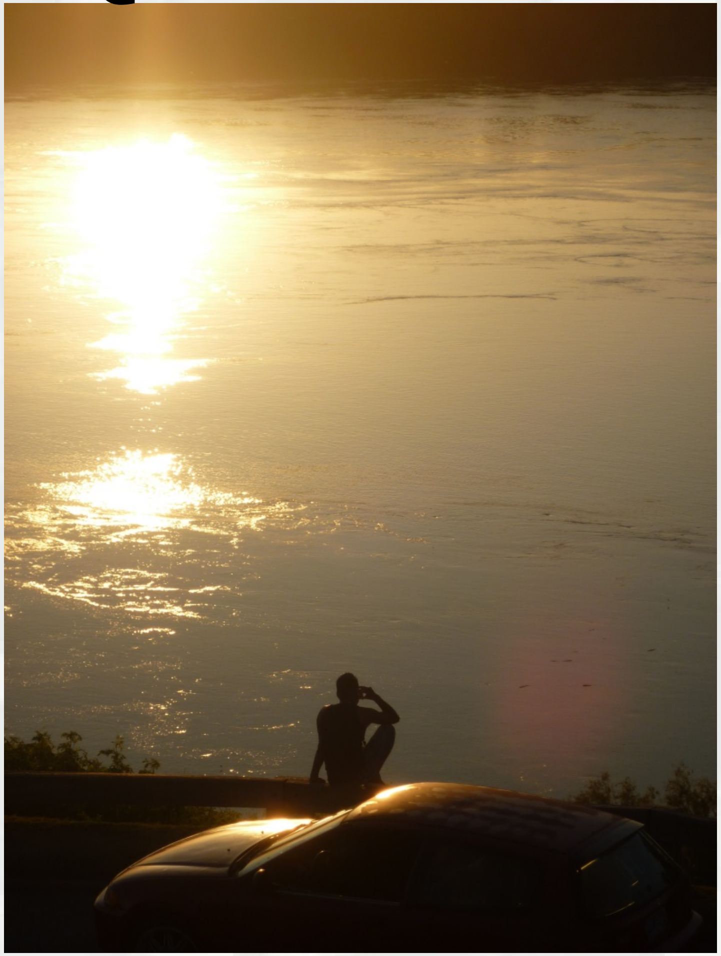
Questions?



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