NCEAS Tidal Wetland Working Group

John Callaway
Department of Environmental Science
University of San Francisco

NCEAS?

- Supported by National Science Foundation
- Designed to bring together working groups to address ecological issues in need of synthesis
- Typically little or no new data collection

- Our Working Group: Tidal wetland carbon sequestration and greenhouse gas emissions model

NCEAS Working Group Members

- John Callaway, USF
- Steve Crooks, ESA PWA
- Pat Megonigal, Smithsonian Env. Res. Center
- Abe Doherty, CA Coastal Conservancy
- Rich Ambrose, UCLA
- Omar Aziz, USGS
- Chris Craft, Univ. of Indiana
- Steve Faulkner, USGS
- Jason Keller, Chapman Univ.
- Sian Mooney, Boise State Univ.
- Jim Morris, Univ. of South Carolina
- Enrique Reyes, East Carolina Univ.
- Lisa Schile, UC Berkeley
- Lisa Marie Windham, USGS


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Pat Megonigal
Omar Aziz
Sian Mooney

Working Group Goals

- Develop a model to predict carbon sequestration rates for tidal wetlands
- Develop policy paper on tidal wetland carbon sequestration
- Develop outreach materials for policy makers on carbon sequestration

Model Selection

- We considered a range of existing modeling approaches
- Existing models: mineral vs. organic sediment focus
- Also, point-based vs. spatial models
- Challenges of incorporating process-based models on large spatial scale
- We settled on a point-based model:

  MEM II: developed by Jim Morris

Model Assumptions

- Focusing on 100-year time scale
- Marsh stability is a function of elevation
  - driven by: mineral and organic matter accumulation, as well as SLR
- Restored wetlands will function similar to natural wetlands (long-term data are from natural wetlands)
- Sequestration focuses on refractory carbon, but restoration credit could also be given for shorter-term accumulation

Marsh Equilibrium Model (MEM II)

- Change in elevation is a function of both inorganic and organic matter accumulation
- Inorganic accumulation = f(suspended sediment concentration, elevation, and biomass)
- Organic accumulation = f(productivity, decomposition rate, and percent of biomass that is refractory)
- Biomass production is affected by elevation and peaks at intermediate elevation
- Carbon sequestration is determined directly as mass-based rate of accumulation over time (and is dependent upon wetland elevation)

142 cm NAVD88 @ 141 days

$$dS/dt \approx mqD$$

less frequently flooded

111 cm NAVD88 @141 days

22 cm NAVD88 @ 43 days

more frequently flooded

Jim Morris
Univ. South Carolina

Plant Biomass:

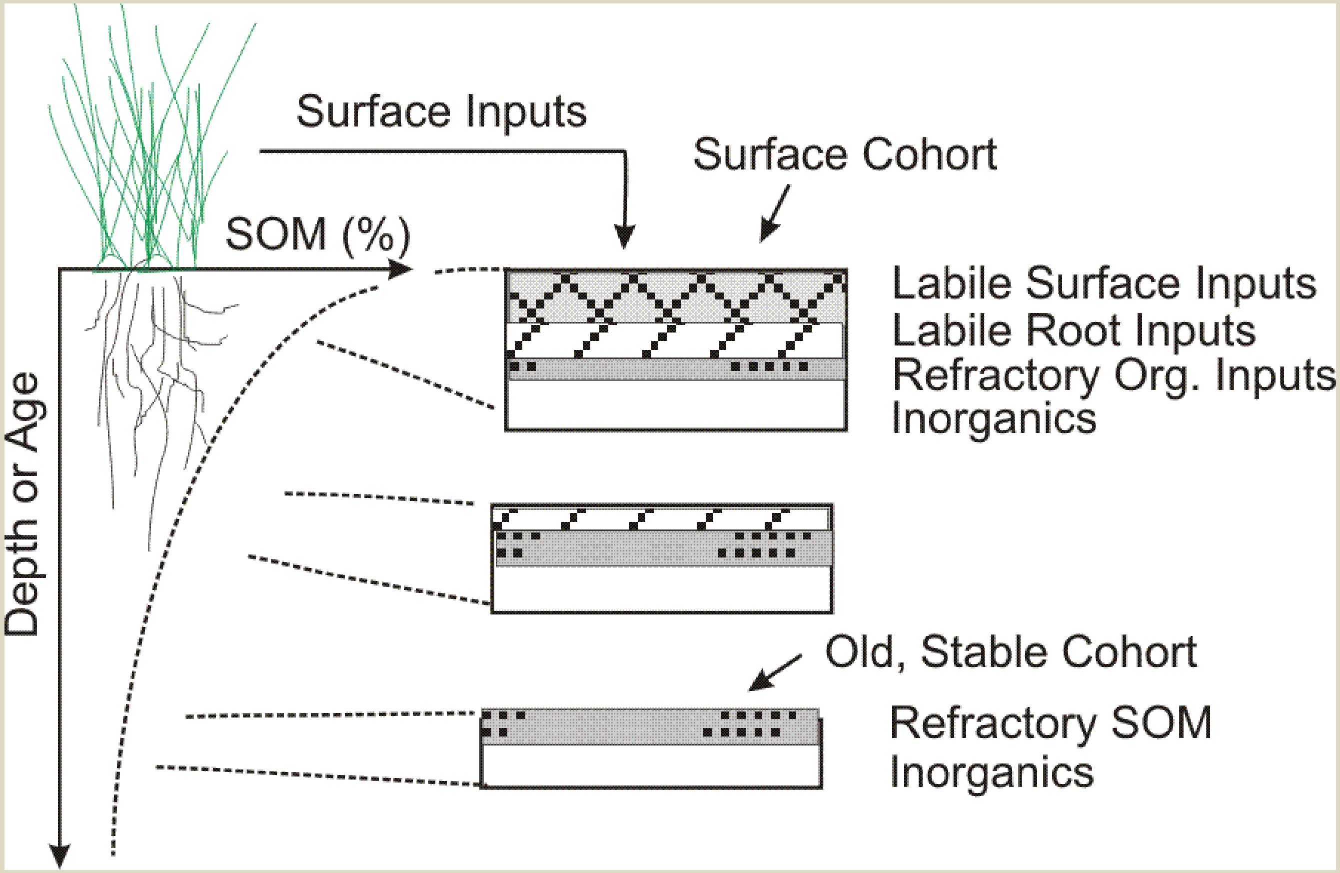
- Trap sediment
- Grow roots & rhizomes

$dS/dt \approx mk_s B_s D$

$dS/dt \approx k_r B_s$

Jim Morris
Univ. South Carolina

Labile and Refractory Components of Marsh Sediments

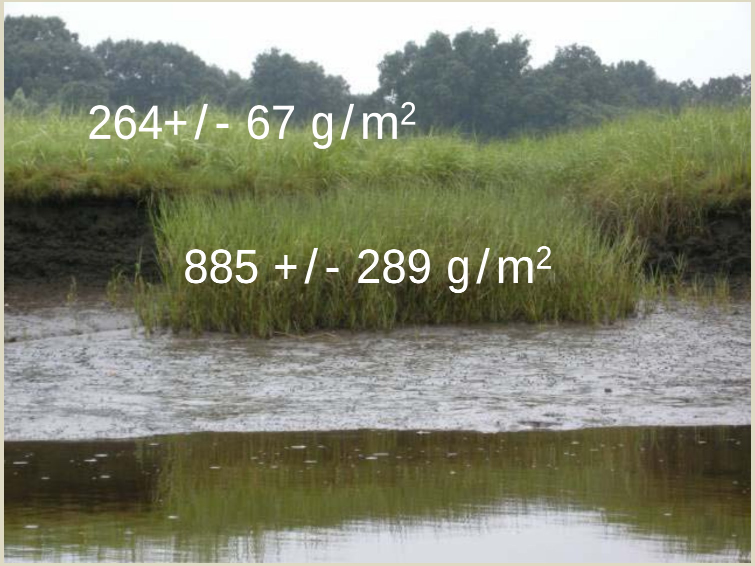


Morris, J.T. and W.B. Bowden. 1986. A mechanistic, numerical model of sedimentation, mineralization, and decomposition for marsh sediments. Soil. Sci. Soc. Amer. J. 50:96-105.

Jim Morris
Univ. South Carolina

The Third Leg: The Plant Response to Relative Elevation

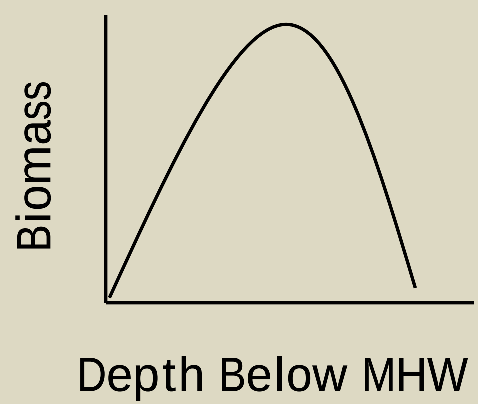
Plum Island



South Carolina

Bioassay in Miss. R. delta

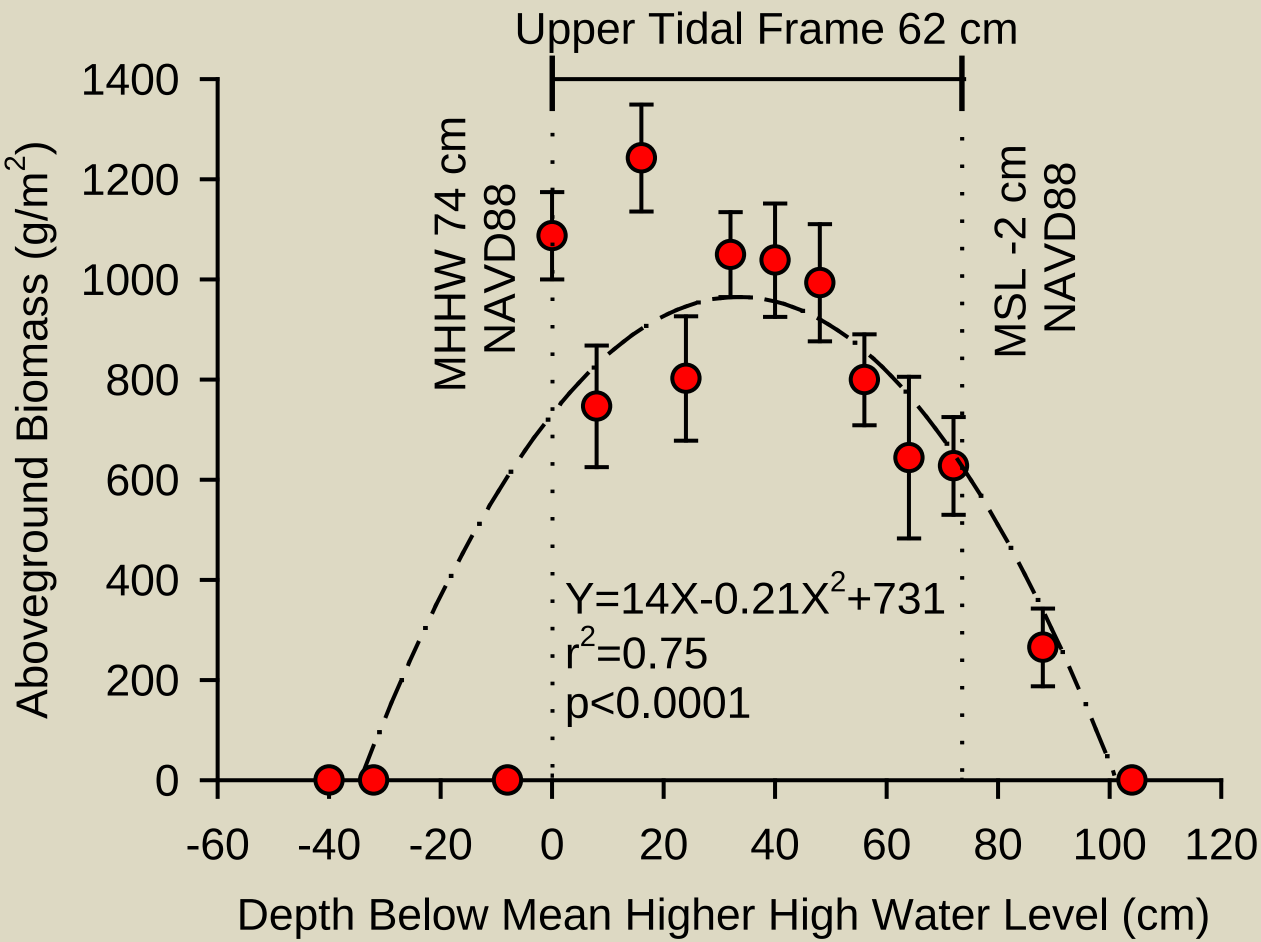
Does not simulate creek banks!



Jim Morris
Univ. South Carolina

Vertical Growth Range of *Spartina alterniflora* at North Inlet

$$B_s = aD + bD^2 + c$$



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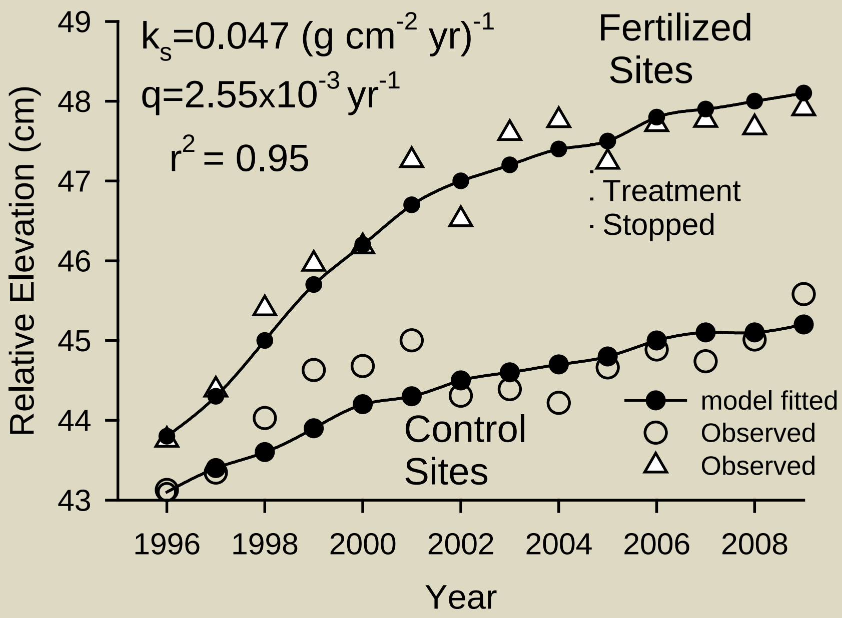
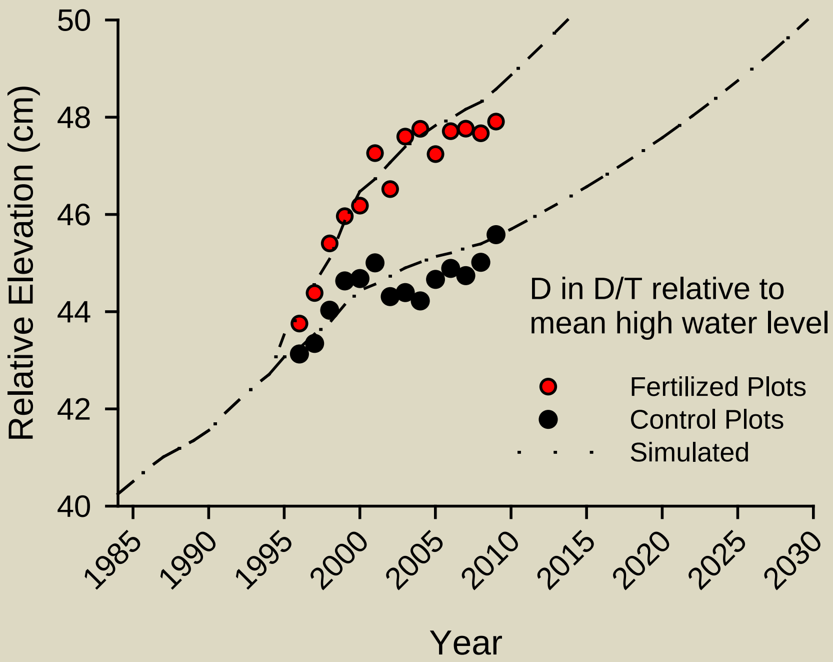
Model Output for North Inlet

Model fit using SET data



Model hindcast and forecast



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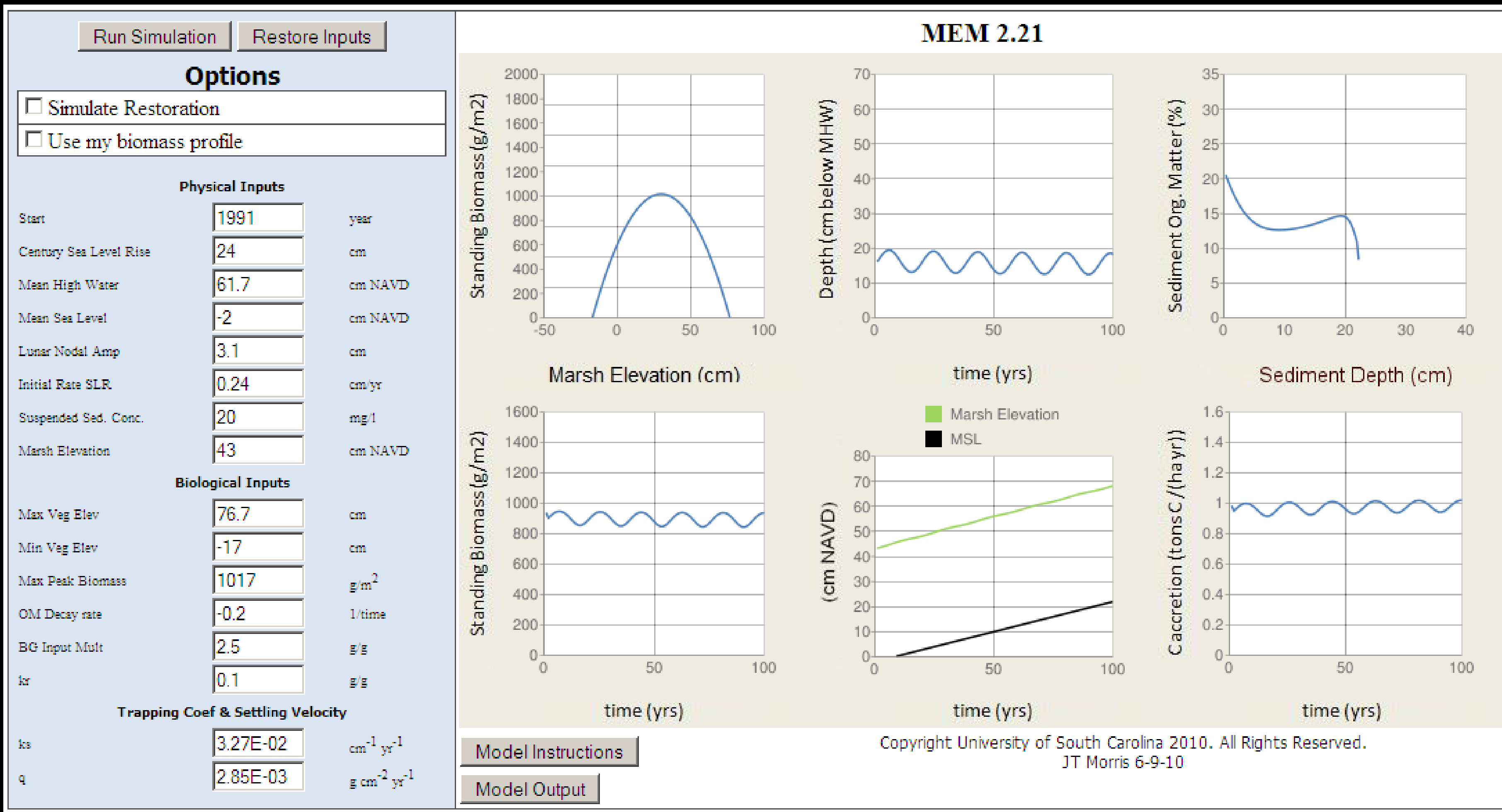
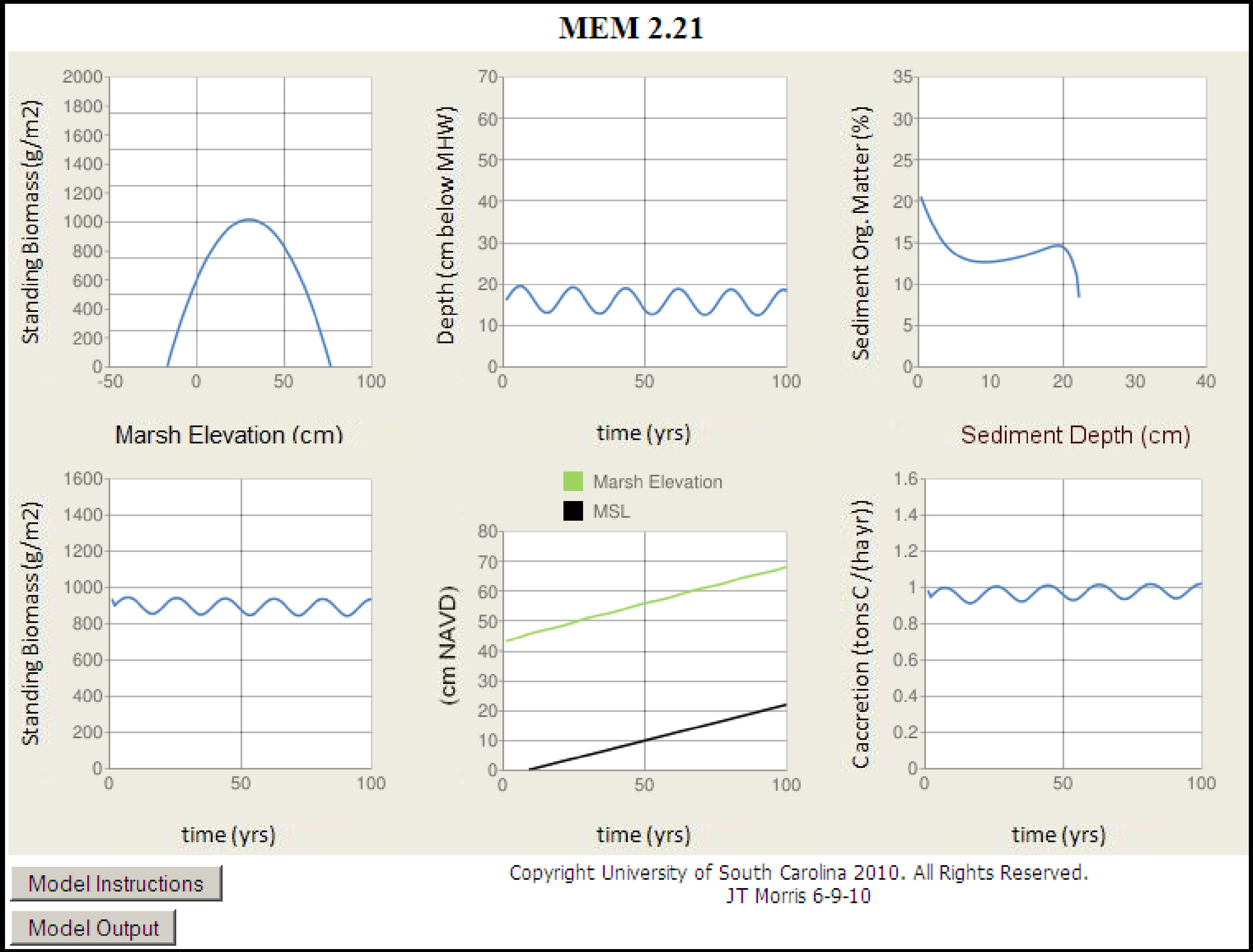
MEM II Model Interface



http://jellyfish.geol.sc.edu/model/marsh/mem.asp

Marsh Development: HISTORIC CONDITIONS



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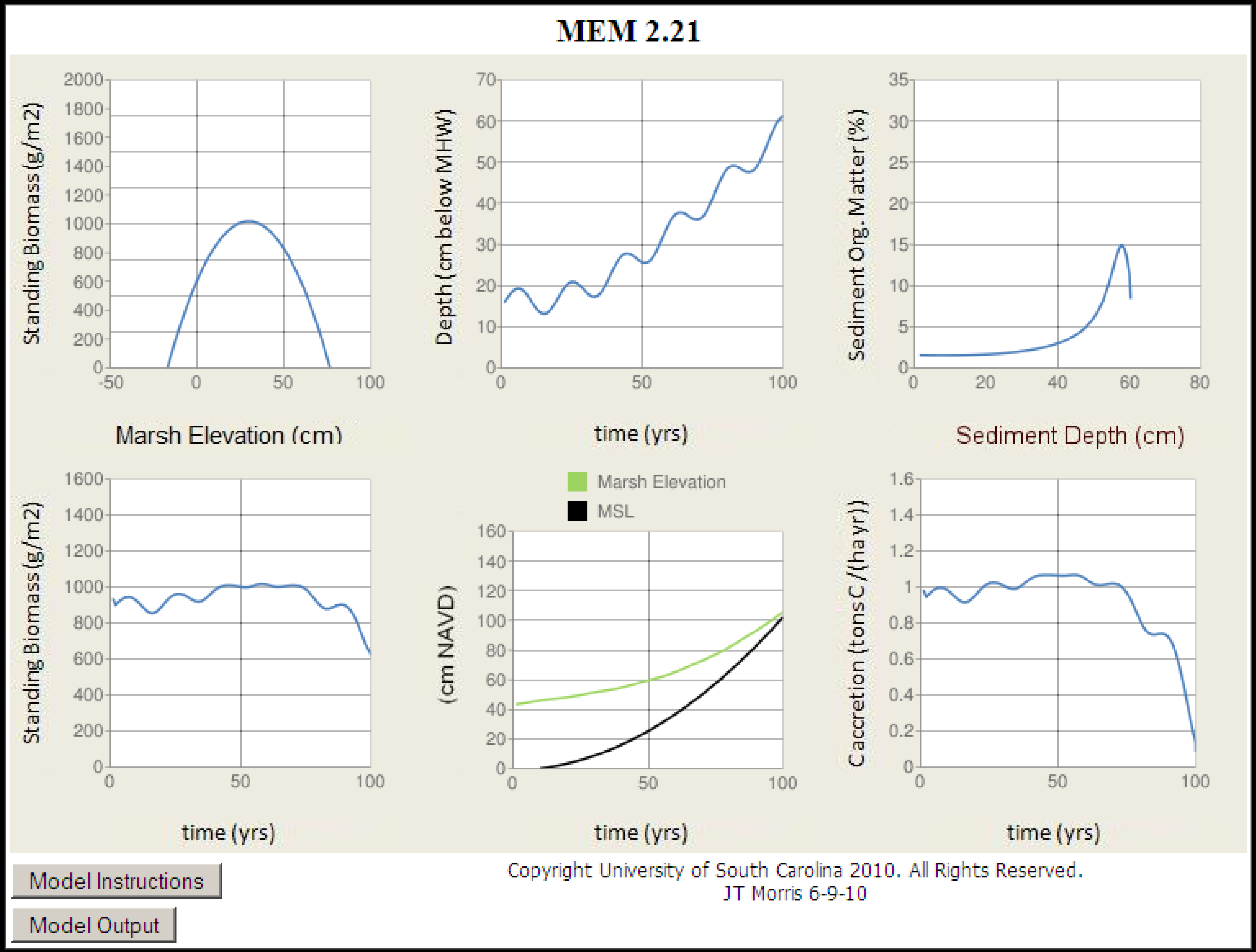
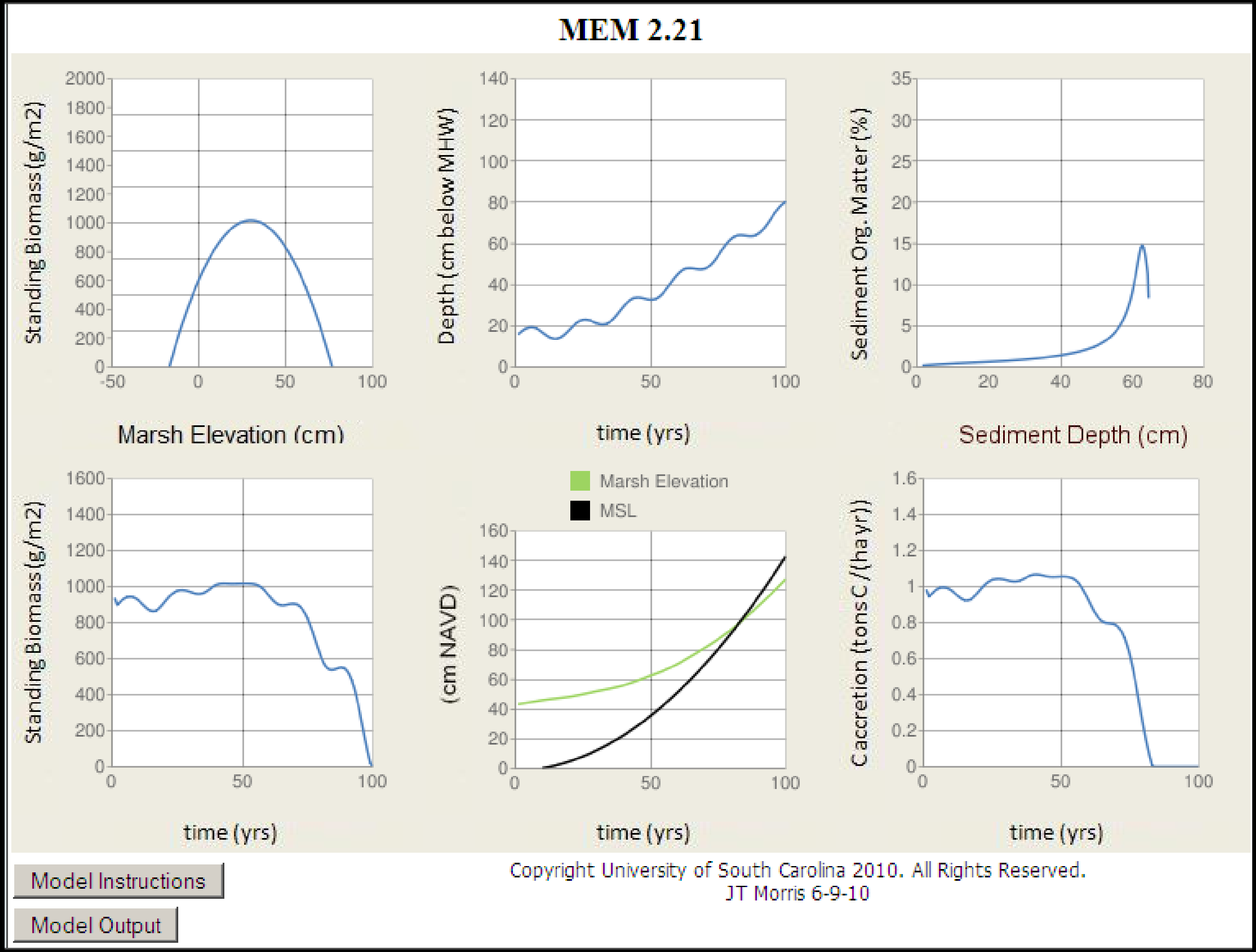
Marsh Development: 100 cm SLR over 100 years



http://jellyfish.geol.sc.edu/model/marsh/mem.asp

Marsh Development: 140 cm SLR over 100 years



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Model Inputs: Sea-Level Rise

Run Simulation | Restore Inputs

Options

- ☐ Simulate Restoration
- ☐ Use my biomass profile

Physical Inputs		
Start	1991	year
Century Sea Level Rise	100	cm
Mean High Water	61.7	cm NAVD
Mean Sea Level	-2	cm NAVD
Lunar Nodal Amp	3.1	cm
Initial Rate SLR	0.24	cm/yr
Suspended Sed. Conc.	20	mg/l
Marsh Elevation	43	cm NAVD
Biological Inputs		
Max Veg Elev	76.7	cm
Min Veg Elev	-17	cm
Max Peak Biomass	1017	g/m^2
OM Decay rate	-0.2	1/time
BG Input Mult	2.5	g/g
kr	0.1	g/g
Trapping Coef & Settling Velocity		
ks	3.27E-02	$cm^{-1}\ yr^{-1}$
q	2.85E-03	$g\ cm^{-2}\ yr^{-1}$

Run Simulation | Restore Inputs

Options

- ☐ Simulate Restoration
- ☐ Use my biomass profile

Physical Inputs		
Start	1991	year
Century Sea Level Rise	140	cm
Mean High Water	61.7	cm NAVD
Mean Sea Level	-2	cm NAVD
Lunar Nodal Amp	3.1	cm
Initial Rate SLR	0.24	cm/yr
Suspended Sed. Conc.	20	mg/l
Marsh Elevation	43	cm NAVD
Biological Inputs		
Max Veg Elev	76.7	cm
Min Veg Elev	-17	cm
Max Peak Biomass	1017	g/m^2
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Additional Model Inputs

Run Simulation | Restore Inputs

Options

- ☐ Simulate Restoration
- ☐ Use my biomass profile

Physical Inputs

Start	1991	year	
Century Sea Level Rise	140	cm	
Mean High Water	61.7	cm NAVD	Tidal range
Mean Sea Level	-2	cm NAVD	Tidal range
Lunar Nodal Amp	3.1	cm	
Initial Rate SLR	0.24	cm/yr	
Suspended Sed. Conc.	20	mg/l	Suspended sediment concentration
Marsh Elevation	43	cm NAVD	

Biological Inputs

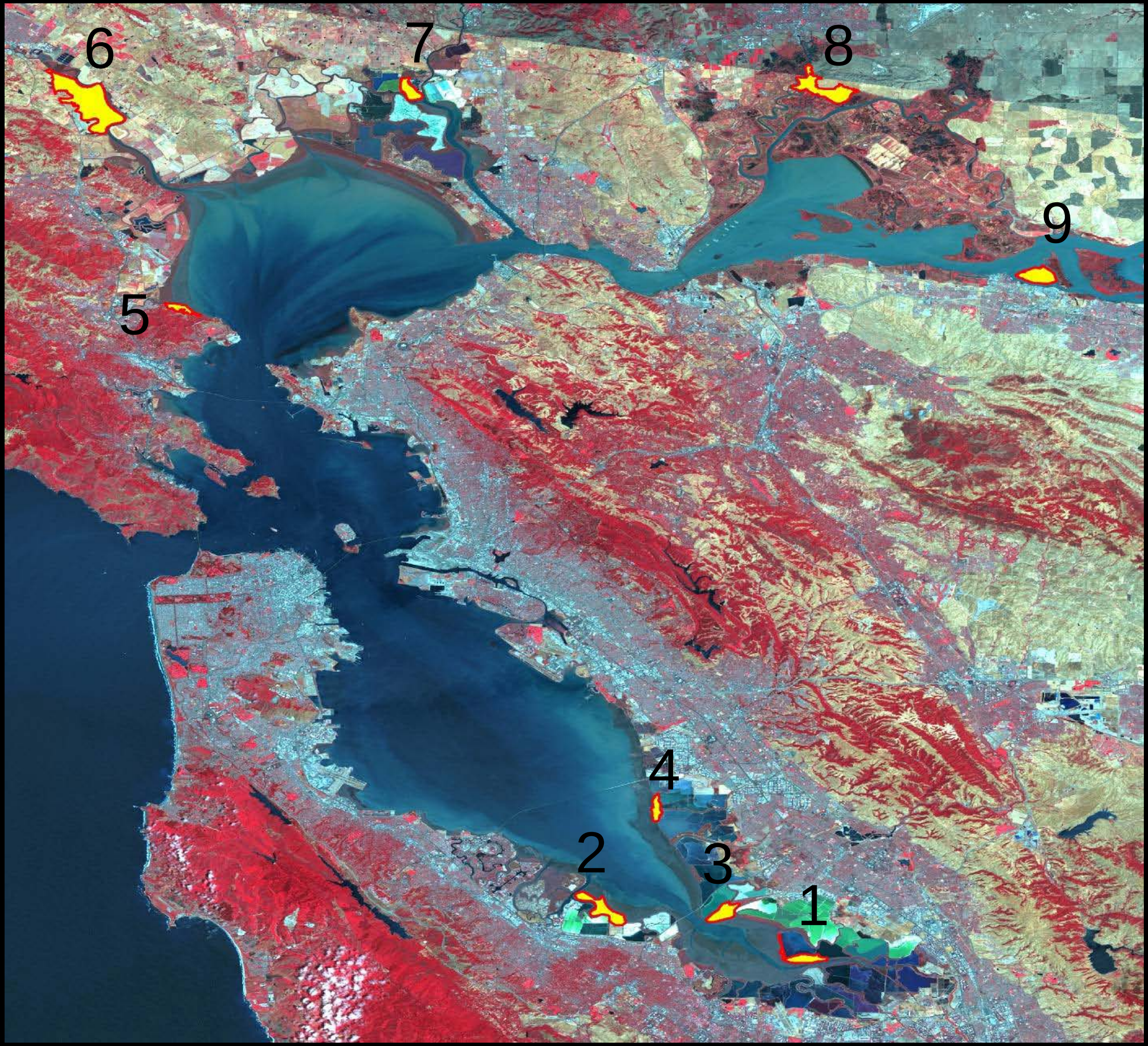
Max Veg Elev	76.7	cm	Vegetation distribution
Min Veg Elev	-17	cm	Vegetation distribution
Max Peak Biomass	1017	g/m^2	Peak biomass
OM Decay rate	-0.2	1/time	Decomposition & below-ground biomass
BG Input Mult	2.5	g/g	Decomposition & below-ground biomass
kr	0.1	g/g	Decomposition & below-ground biomass

Trapping Coef & Settling Velocity

ks	3.27E-02	$cm^{-1}\ yr^{-1}$	Mineral sediment settling
q	2.85E-03	$g\ cm^{-2}\ yr^{-1}$	Mineral sediment settling

http://jellyfish.geol.sc.edu/model/marsh/mem.asp

Large-scale spatial variation: based on salinity gradient



Within marsh variation: based on plant communities

Additional Model Considerations

- Methane
  - plan to use simple approach for initial model
    - salinity
    - elevation (inundation)
    - sediment organic matter
- Initial calibration sites
  - North Inlet, South Carolina
  - San Francisco Bay, California
  - Sapelo Island, Georgia
  - Mississippi River Delta, Louisiana

Future Developments

- Incorporate hydrology/spatial dynamics
- Dynamic salinity variable
- Broader range of site
- Improve modeling of methane and nitrous oxide

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