

# "Blue" Carbon Monitoring System



## Linking Satellite and Soil Data to Validate Coastal Wetland 'Blue Carbon' Inventories: Upscaled Support for Developing MRV and REDD+ Protocols

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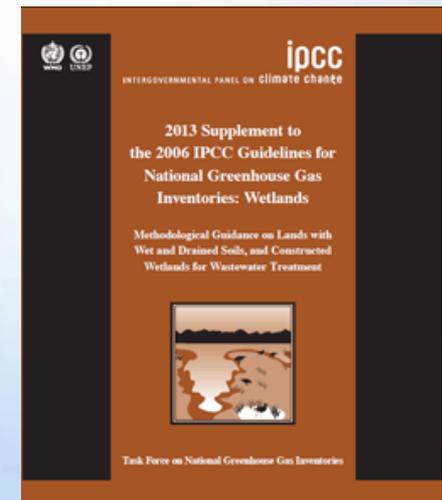
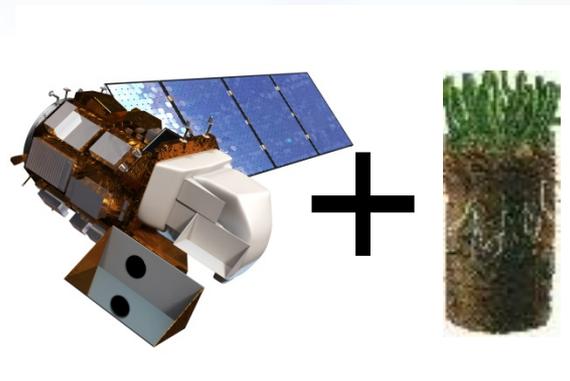
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Pat Megonigal  
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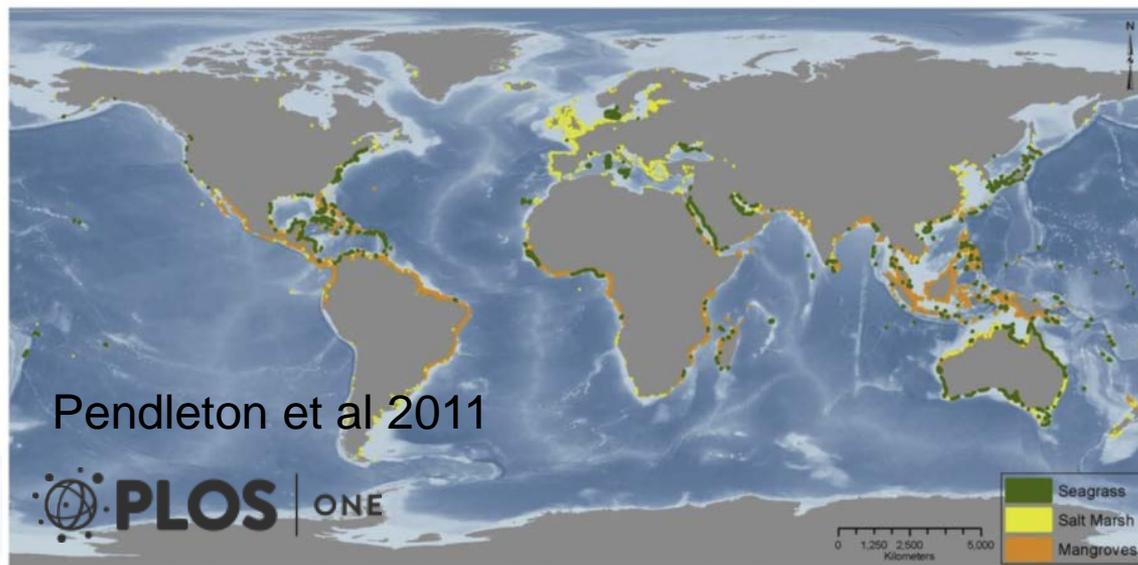
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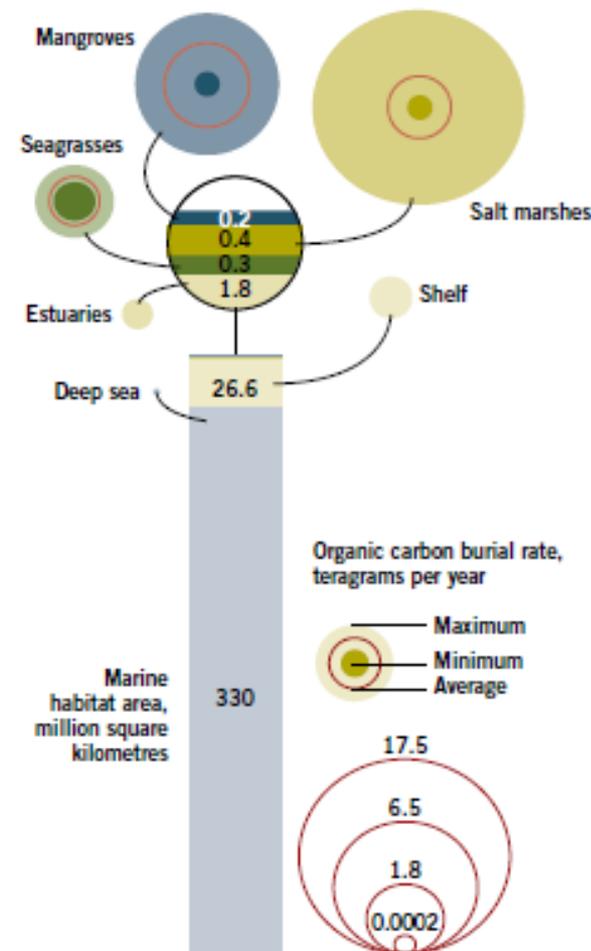


# "Blue" CMS - Background



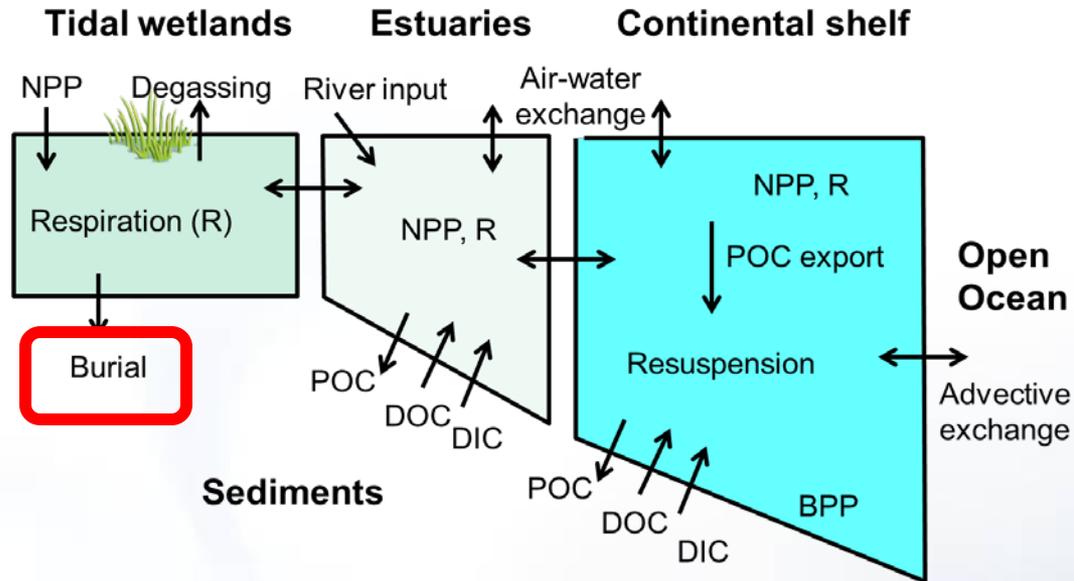
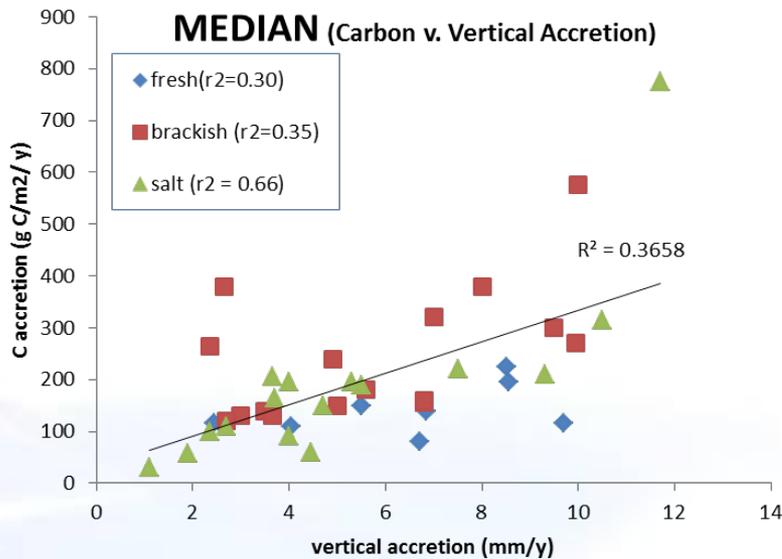
Coastal Ocean: depth < 200m	Pg C yr <sup>-1</sup>	% ocean total
Primary Production	6.5	12
Export Production	2.0	21
Burial	0.67	86

Figure 1 Blue carbon sinks



Sources: Brock et al. 2012; Nellemann et al. 2009.

# "Blue" CMS - Questions



Can LULC data be used for national GHG inventory?  
IPCC Stock Difference (1990-2010)

Can we reduce uncertainty by refining wetland categories?  
(vegetation type, biomass, elevation, salinity, sediment)

# “Blue” CMS – Policy-Driven Needs



Drained freshwater tidal peatland,  
San Francisco Bay-Delta (USGS)

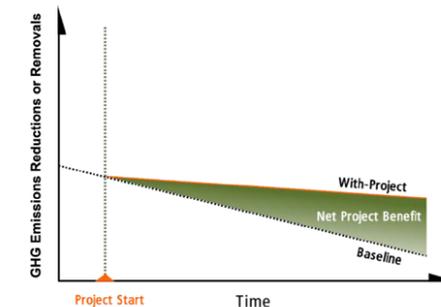
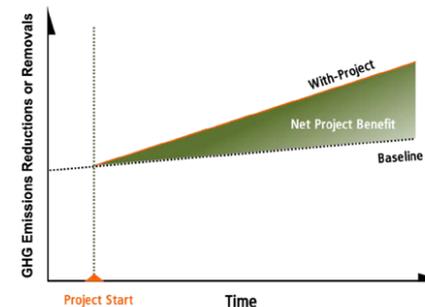
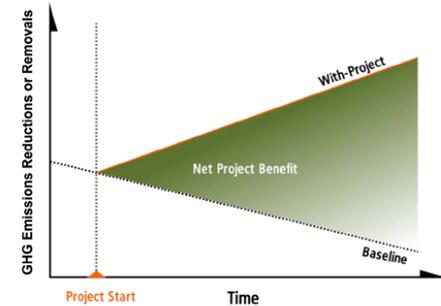
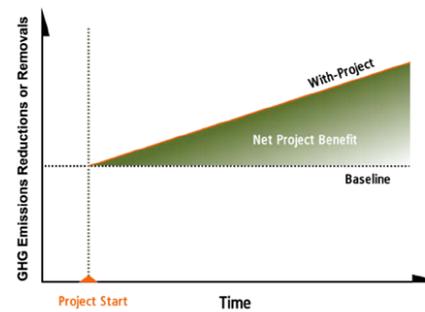
## 1. IPCC Wetlands Suppl. 2013 (Ch.4 Coastal)

### Mangrove and Tidal Marsh **Activities:**

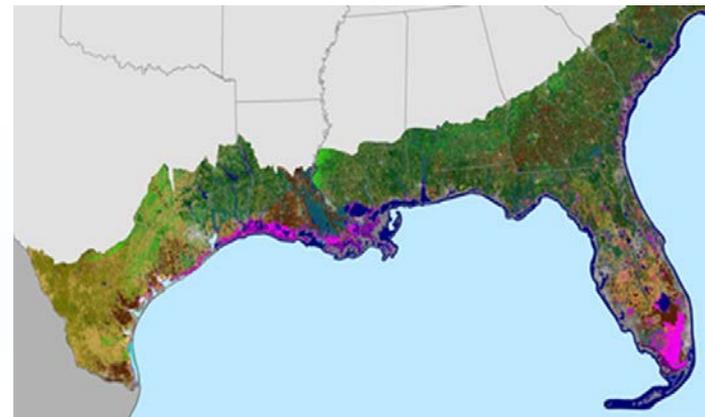
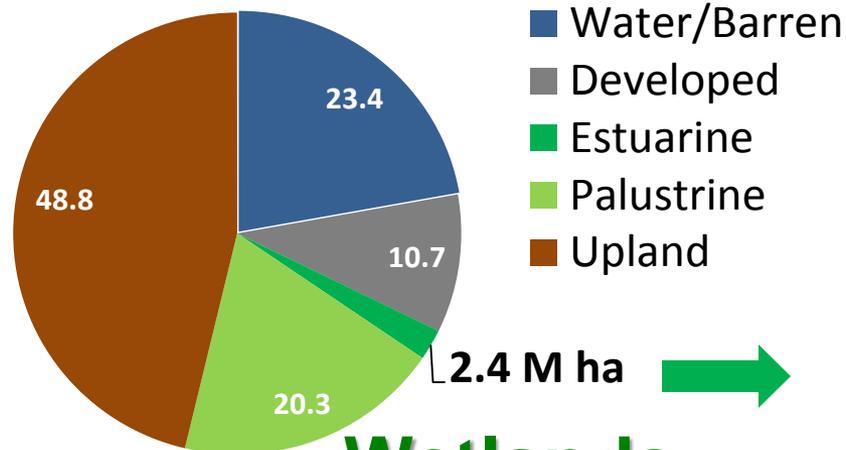
- CO<sub>2</sub> Forest management  
Extraction  
Drainage  
Rewetting/Revegetation/Creation
- CH<sub>4</sub> Rewetting/Revegetation/Creation

## 2. REDD+ and US agency policies (soil C)

## 3. Market Incentives (VCS, ACR)

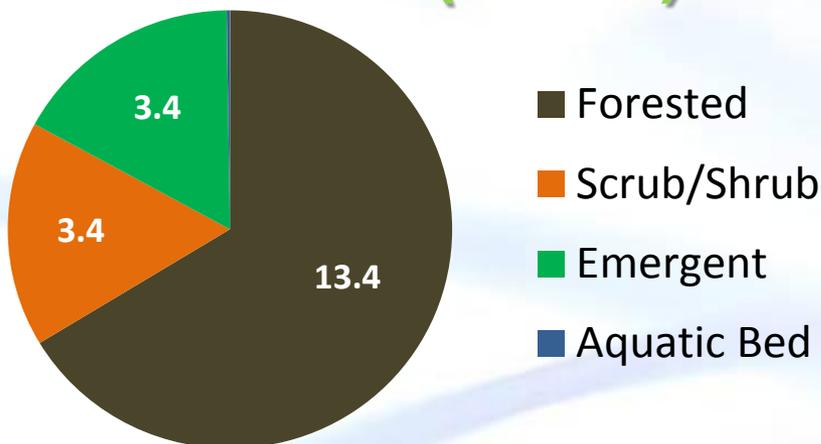


# U.S. NOAA C-CAP 2010 – tidal wetlands

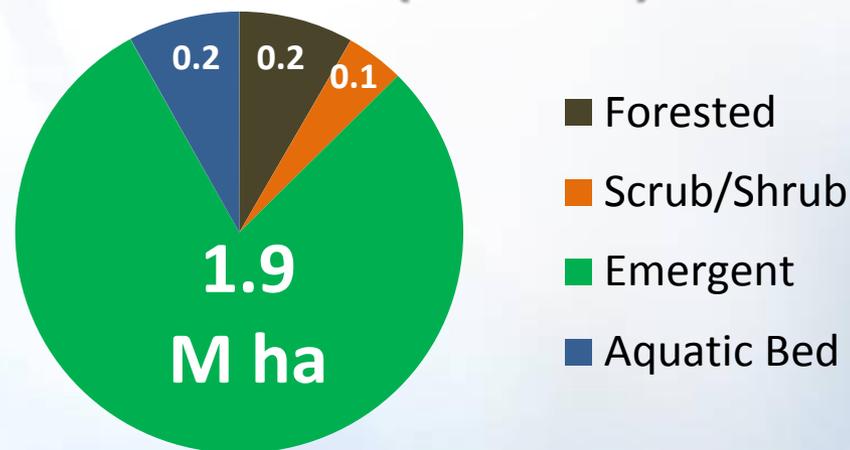


**Wetlands  
23 M ha**

**Palustrine (Fresh)**



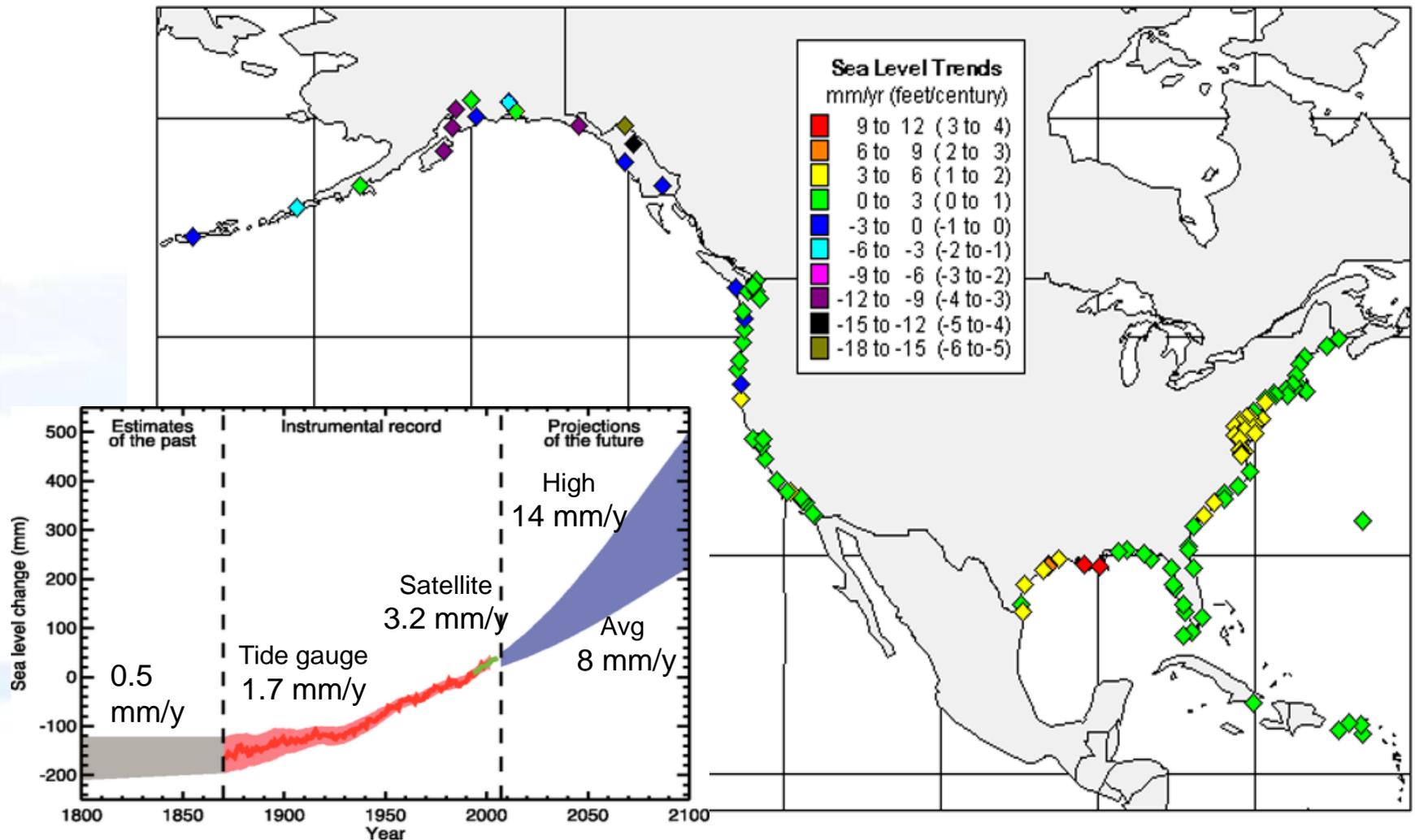
**Estuarine (Saline)**



**IPCC Default sed burial = 3.2 Tg**  
**(2.3Mha x 1.4T ha<sup>-1</sup> y<sup>-1</sup>)**

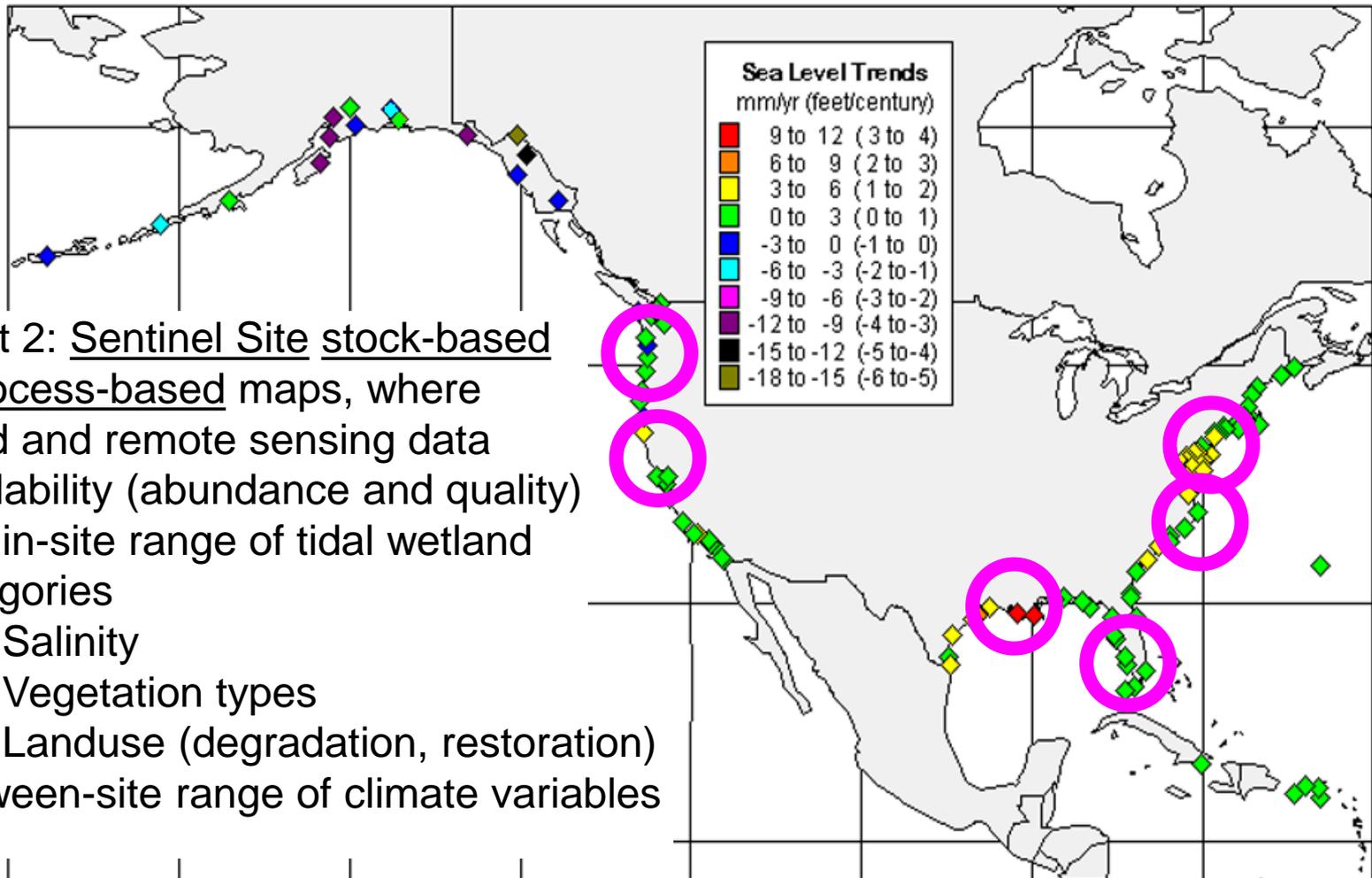
# "Blue" CMS - Approach

Product 1: National Scale stock-based 30m resolution C pool maps (1992-2010) via NOAA's C-CAP (NLCD) linked with regional SLR and SSURGO 1m soil data



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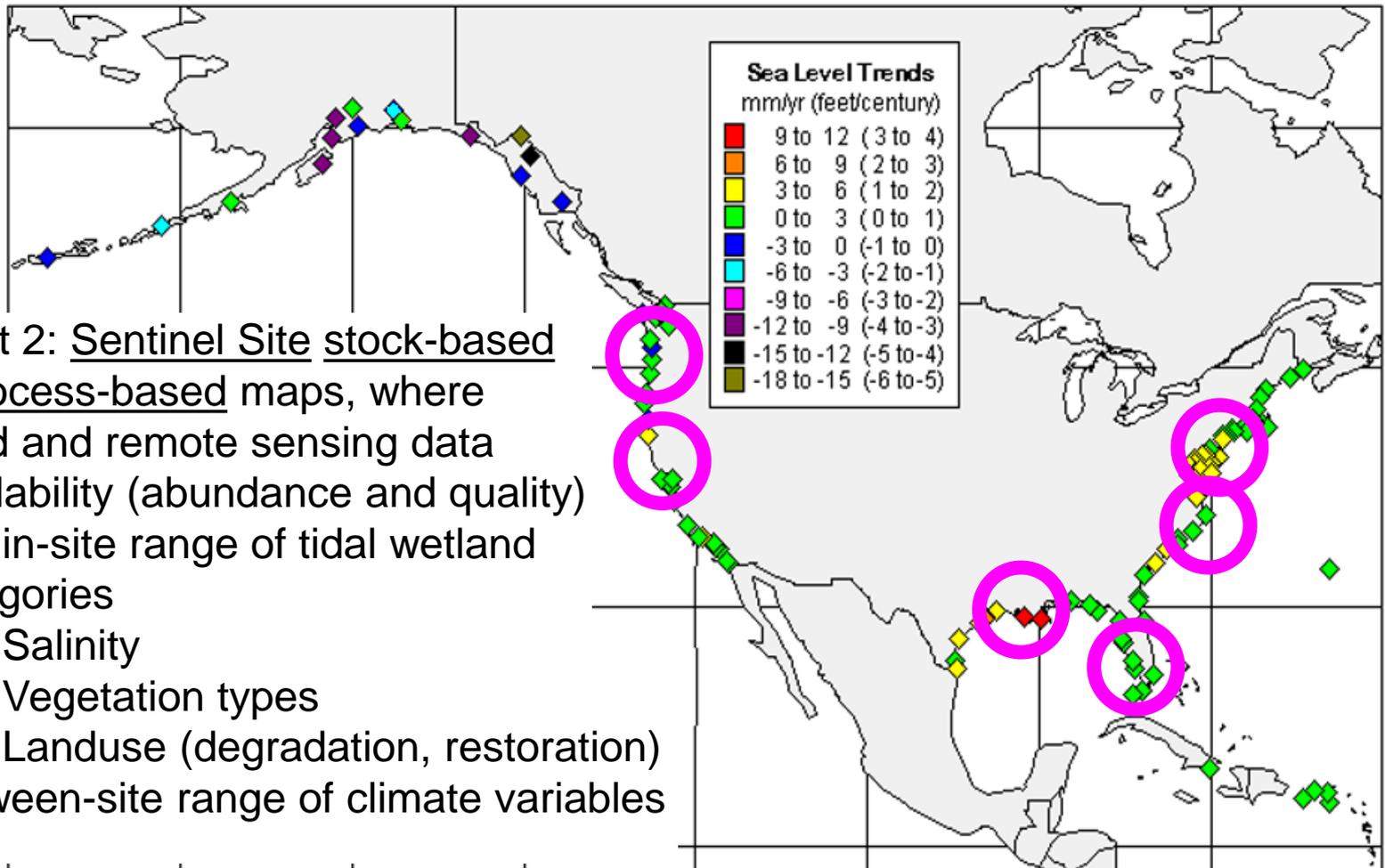
Product 2: Sentinel Site stock-based and process-based maps, where

- Field and remote sensing data availability (abundance and quality)
- Within-site range of tidal wetland categories
  - Salinity
  - Vegetation types
  - Landuse (degradation, restoration)
- Between-site range of climate variables

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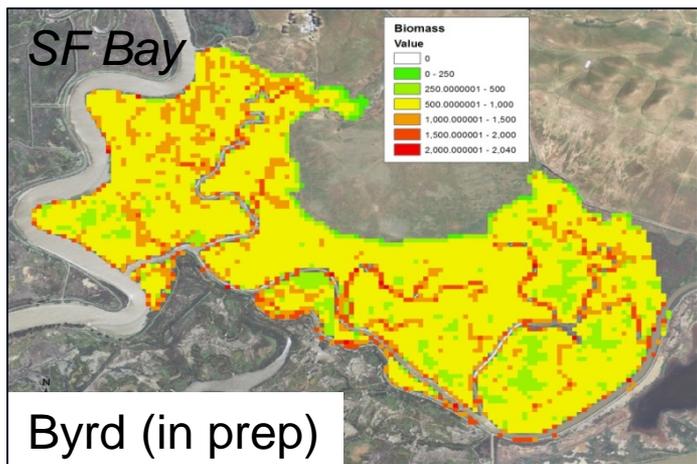


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Product 3: Price of Precision Error Analysis (30m v 250m, Tier 1,2,3, Algorithms)

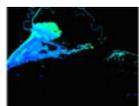
# "Blue" CMS – Remote Sensing



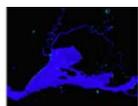
Byrd (in prep)

Boss et al (in prep)

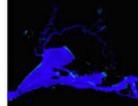
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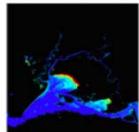
October 9, 2013



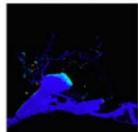
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December 12, 2013



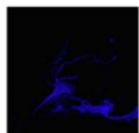
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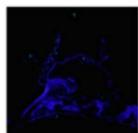
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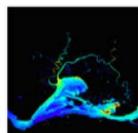
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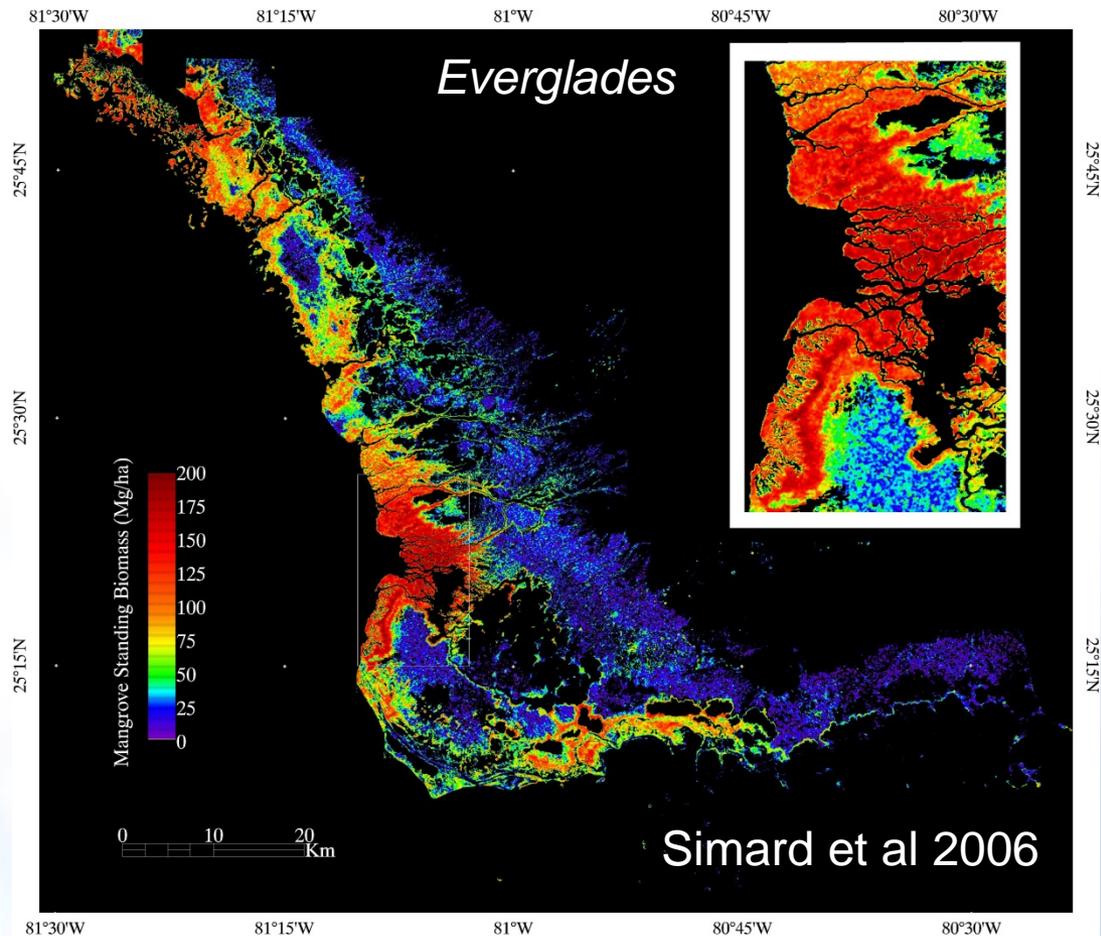
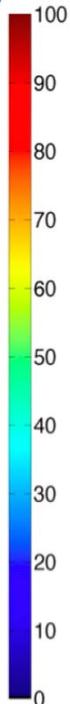
April 19, 2014



May 5, 2014



May 21, 2014



	Sensor	RMSE	%
Biomass ( $T ha^{-1}$ )	Landsat8 (marsh)	3.3	14
	SRTM (mangrove)	20	20
SSC (mg/L)	Landsat8 (marsh)	3.4	10

# "Blue" CMS – Example Matrix

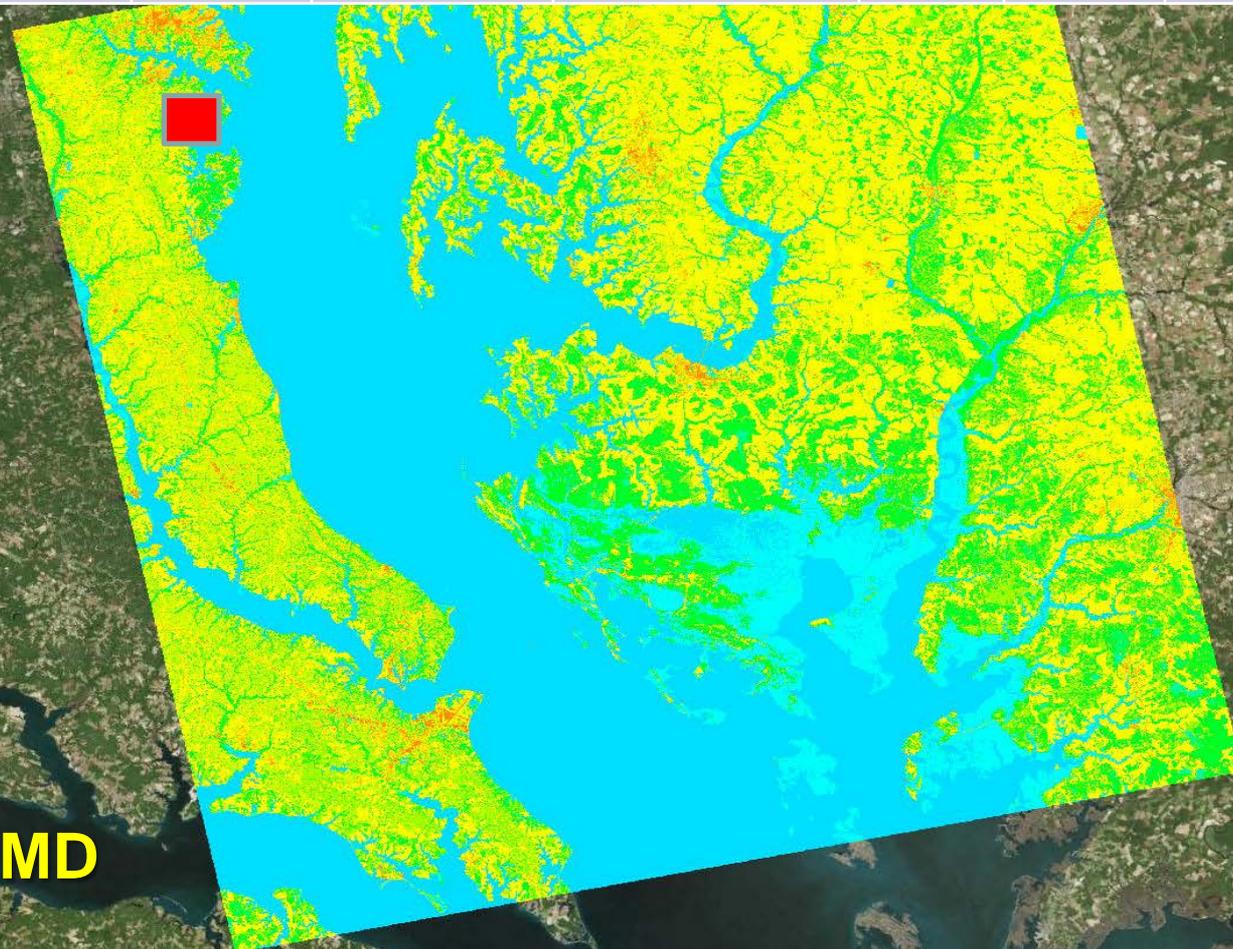


	C-CAP	C-CAP	SSURGO	IPCC Default	USFWS	RS Data	+ field
Date	Hydrology	Vegetation	Soil C stock (T)	Biomass C stock (T)	Salinity	Biomass	calibrate
1992	Cultivated	Crops	24	0	Fresh		
2010	Estuarine	Emergent	26	2	Brackish		

**2006 C-CAP classes**

**Class**

- Developed, High Intensity
- Developed, Medium Intensity
- Developed, Low Intensity
- Developed, Open Space
- Cultivated Crops
- Pasture/Hay
- Grassland/Herbaceous
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Scrub/Shrub
- Palustrine Forested Wetland
- Palustrine Scrub/Shrub Wetland
- Palustrine Emergent Wetland
- Estuarine Forested Wetland
- Estuarine Scrub/Shrub Wetland
- Estuarine Emergent Wetland
- Unconsolidated Shore
- Bare Land
- Open Water
- Palustrine Aquatic Bed
- Estuarine Aquatic Bed
- Snow/Ice



**SERC,**  
**Chesapeake Bay, MD**



# "Blue" CMS – Process-based Model



From past and present, project future

Marsh Equilibrium Model (MEM 5.4):  
mechanistic, annual cohort, 1D accretion



SLR  
SSC

Elevation  
of Peak  
Biomass  
and  
g/m<sup>2</sup>

**Options**

Use my biomass profile

Biomass Seasonality

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**Physical Inputs**

Century Sea Level Rise	52	cm
Mean High Water	198	cm NAVD
Mean Sea Level	110	cm NAVD
Initial Rate SLR	0.24	cm/yr
Suspended Sed. Conc.	25	mg/l
Marsh Elevation	180	cm NAVD

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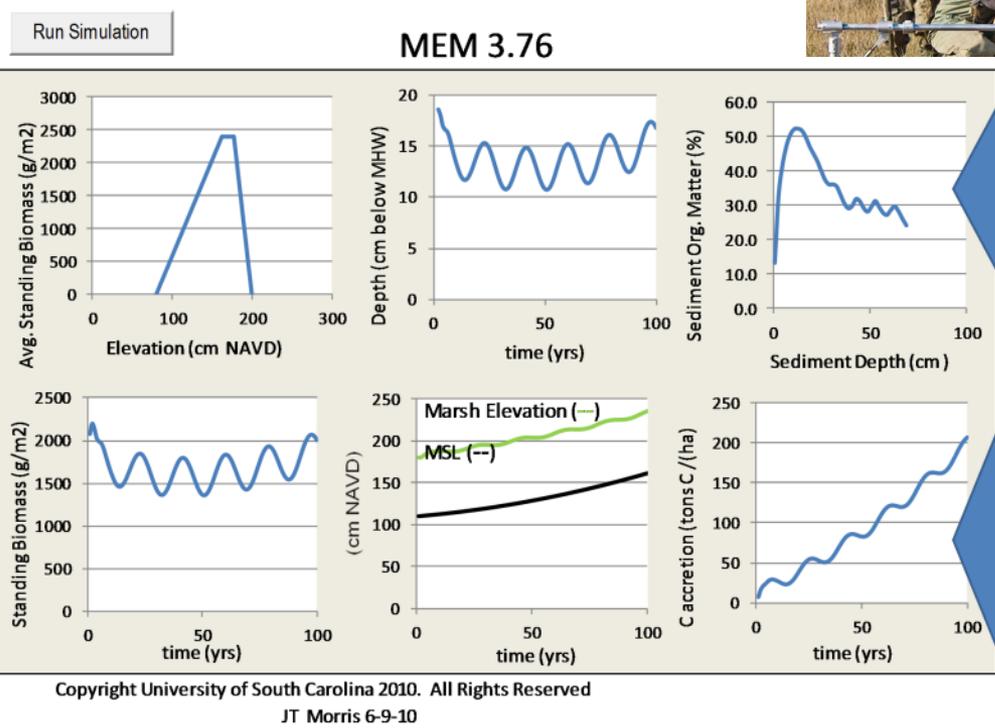
**Biological Inputs**

max elevation	200.0	cm
min elevation	80.0	cm
elev of peak biom	170	cm
max peak biomass	2400	g/m <sup>2</sup>
OM decay rate	-0.2	1/year
GBio to Shoot Ratio	3	g/g
Refrac. Fraction (kr)	0.09	g/g
BG turnover rate	1	1/year
Max (95%) Root Depth	40	cm

---

**Trapping Coef & Settling Velocity**

ks	3.28E-02	cm <sup>-1</sup> yr <sup>-1</sup>
q	1.46E-03	g cm <sup>-3</sup> yr <sup>-1</sup>



Core  
profile for  
hindcast  
validation

Equilibrium  
Long-term  
Carbon  
Accretion  
Rate

MEM-CH4: next version is methane capable

Once calibrated, relative elevation is used to estimate cumulative accretion, water depth, flooding frequency, aboveground and belowground biomass, and carbon stored.

# "Blue" CMS - Goal



Synthesize validation data and metrics known to play a role in coastal carbon accretion  
 Evaluate what data sets, at what scale, are capable of improving C burial estimates

Year	C-CAP	SSURGO	NOAA Tidegauges	USFWS	RS Data	LiDAR DEM	+ field
1996							
2001							
2006							
2010							

GIS Model



Process-based Model

SLR

SSC

Elevation of Peak Biomass and g/m<sup>2</sup>

**Options**

Use my biomass profile

Biomass Seasonality

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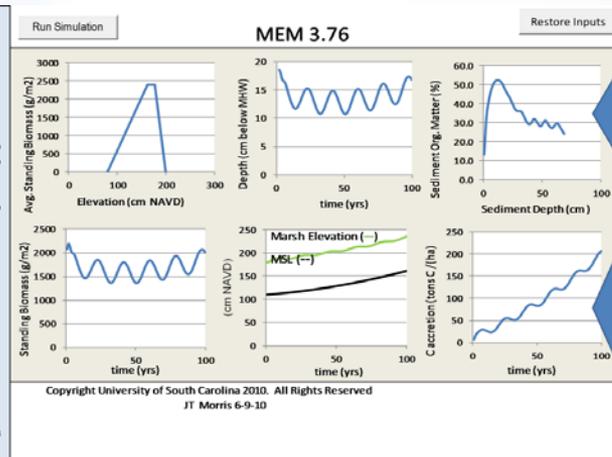
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Core profile for hindcast validation

Equilibrium Long-term Carbon Accretion Rate

= verifiable protocol to support federal, international, and market incentives