"Blue" Carbon Monitoring System (BCMS)

Leveraging field and remotely sensed data to reduce uncertainty in national inventories of coastal wetland carbon fluxes

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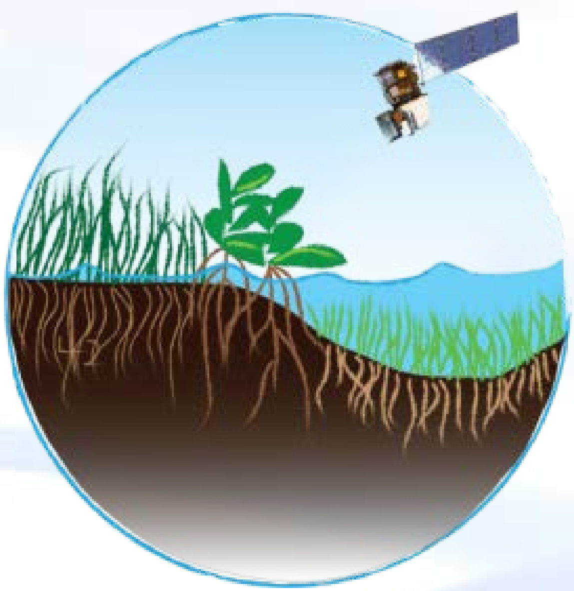
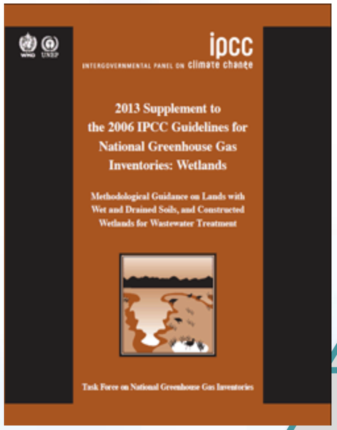
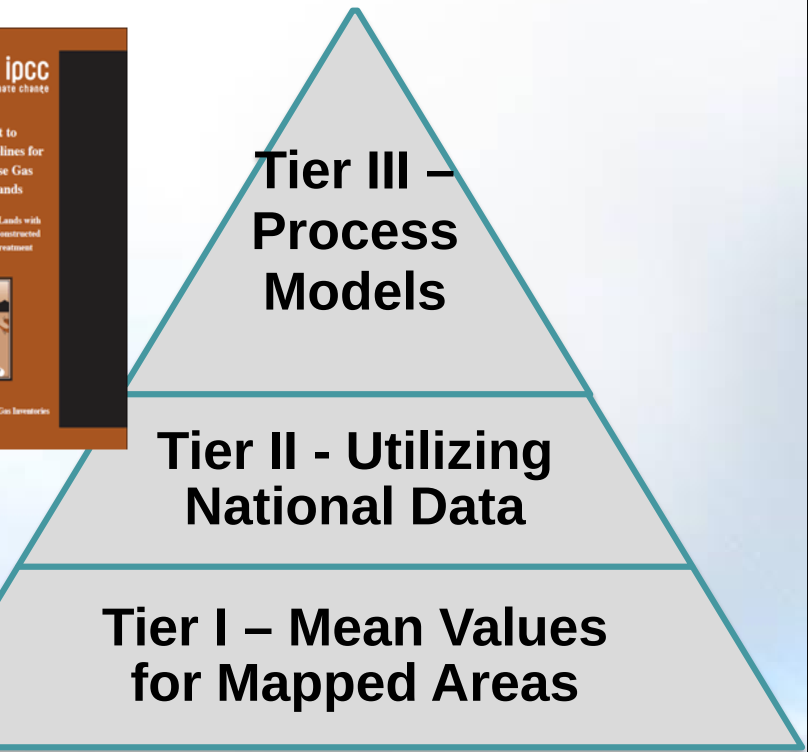



ipcc
INTERGOVERNMENTAL PANEL ON climate change

2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands

Methodological Guidance on Lands with Wet and Drained Soils, and Constructed Wetlands for Wastewater Treatment

Task Force on National Greenhouse Gas Inventories

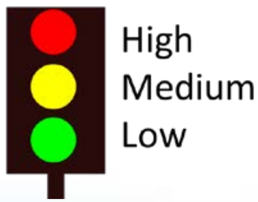


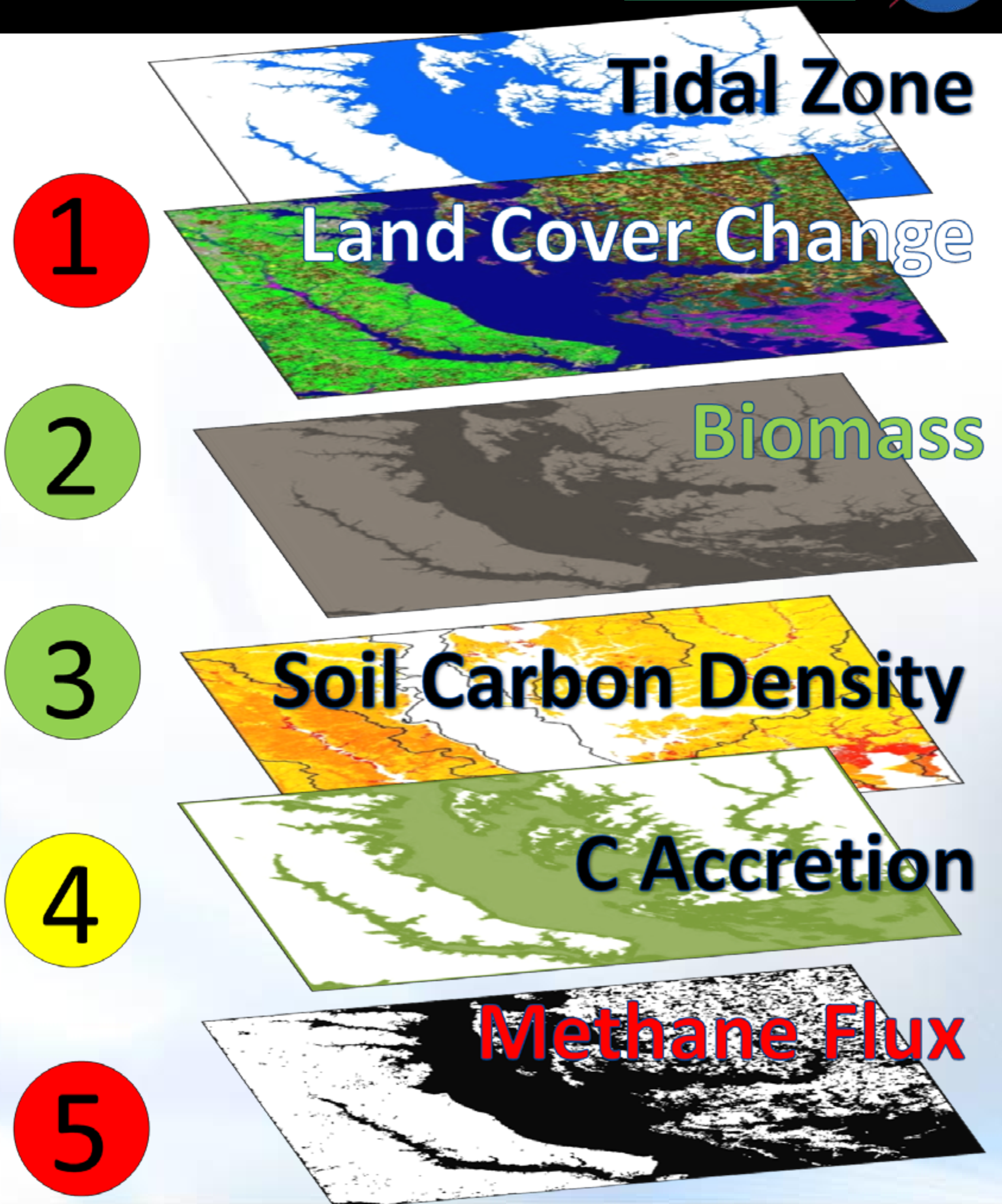
http://water.usgs.gov/nrp/blue-carbon/nasa-blue-cms/

BCMS Goal: to reduce uncertainty

- Land categorization
- Biomass C flux
- Soil C flux
- Methane flux

How uncertain are these national layers?





How much better do they need to be to improve GHG accounting?

Where are the biggest data gaps?

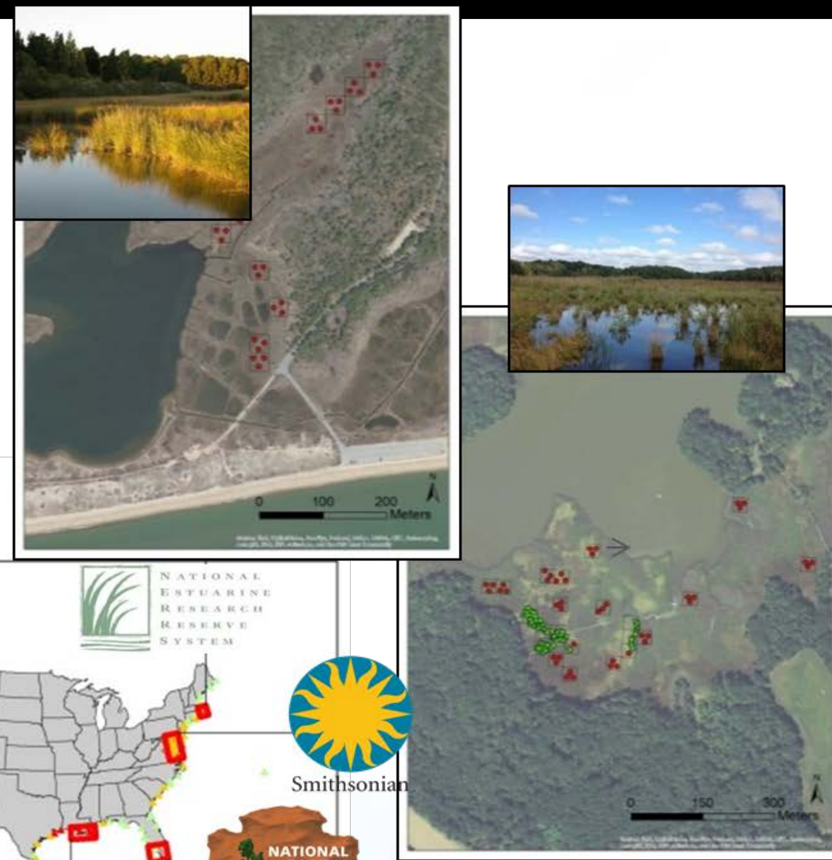
Is the uncertainty with <u>monitoring</u> (quality, coverage) or <u>modeling</u> (process-based understanding)?

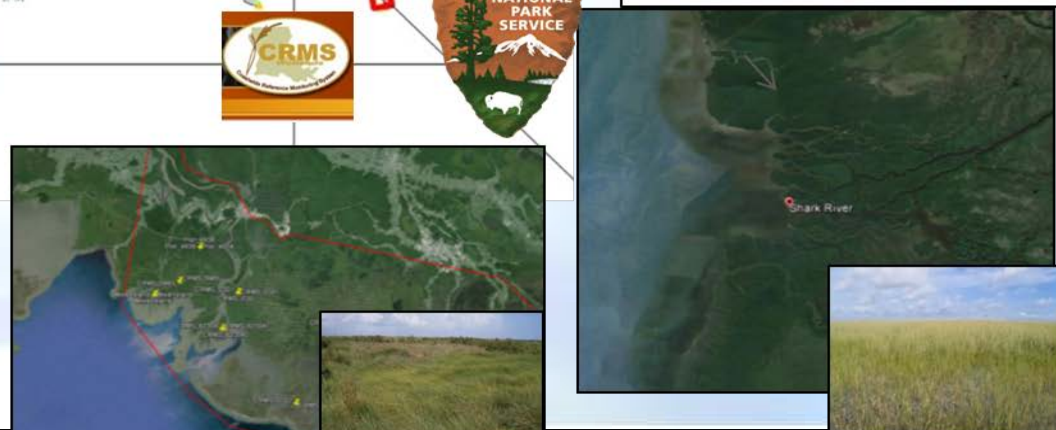
Tidal Marsh Aboveground Biomass

USGS science for a changing world

NASA

N = 6 sentinel sites (wide range)





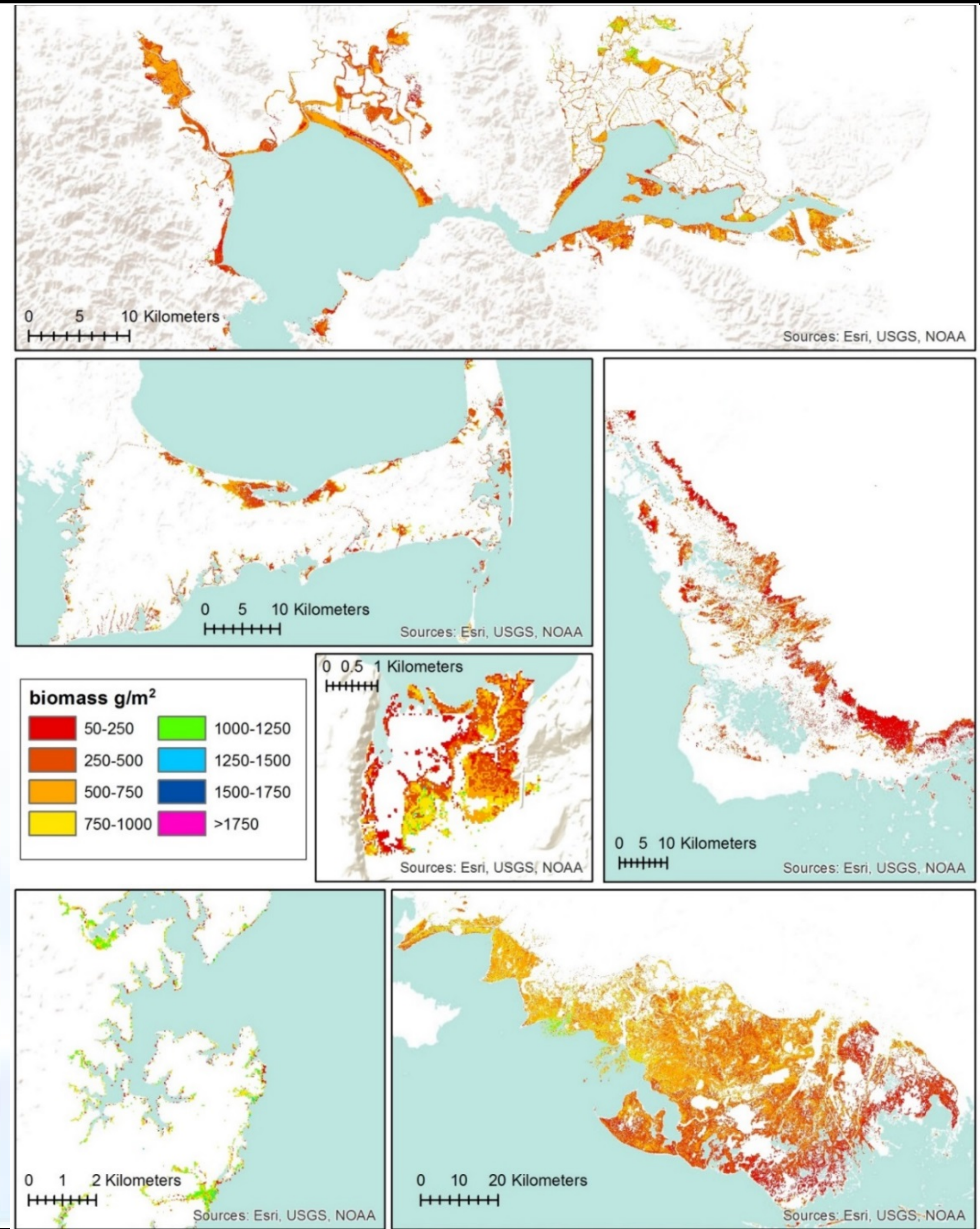
Biomass plots (>2600)

Biomass: *Byrd et al (in review, RSE)*

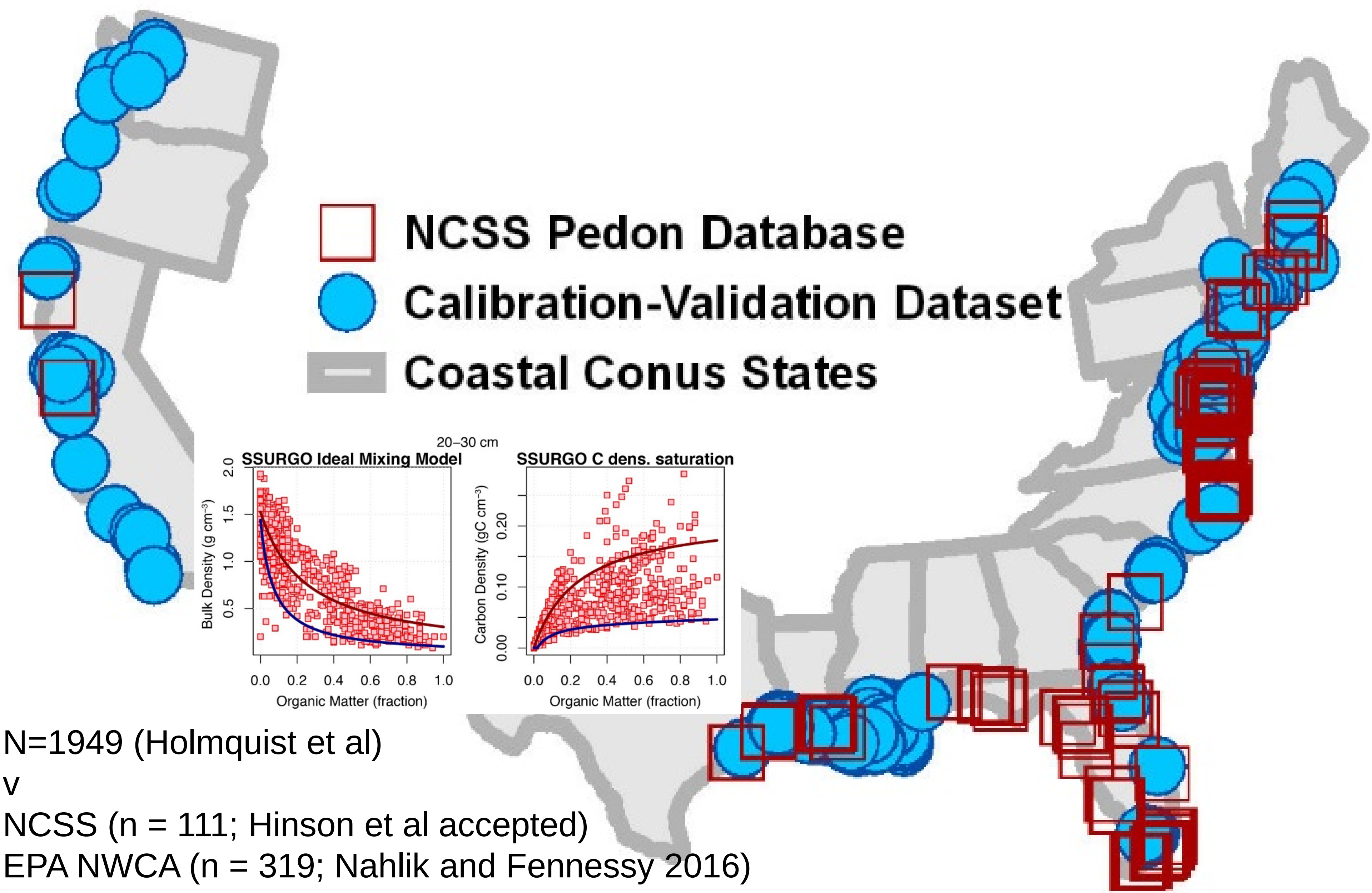
Universal model for annually reproducible maps at 30m resolution for tidal marsh peak biomass based on LandSat and automated 1m NAIP water/soil/vegetation classification (RMSE = 311, $R^2 = 0.58$)

- No added benefit of RADAR
- No strong effect of salinity/site/plant type

Random Forest Ranger Variable	Relative Importance
Soil-adjusted Veg Index	100
Norm.Diff.Red.Green	69
Wide Dynamic Range Veg Index	55
Norm.Diff.Green.Blue	36
Norm.Diff.SWIR2.Red	31
Norm.Diff.SWIR2.NearIR	21
Site.Chesapeake	17
Site.Everglades	7
Site.SanFrancisco Freshwater	6
Site.San Francisco Bay	4
Site.Louisiana	7
Site.Puget Sound	0
Site.CapeCod	0



Tidal Wetland Soil C stock (to 1m)



N=1949 (Holmquist et al)

v

NCSS (n = 111; Hinson et al accepted)

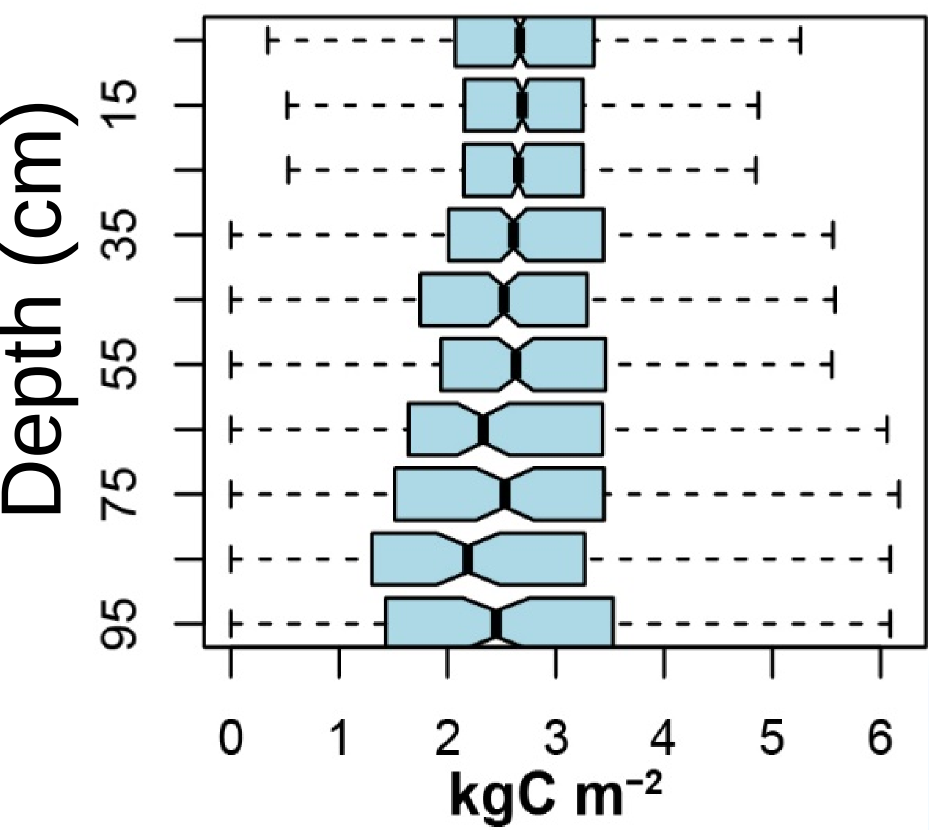
EPA NWCA (n = 319; Nahlik and Fennessy 2016)

Soil C density: *Holmquist et al (in prep)*

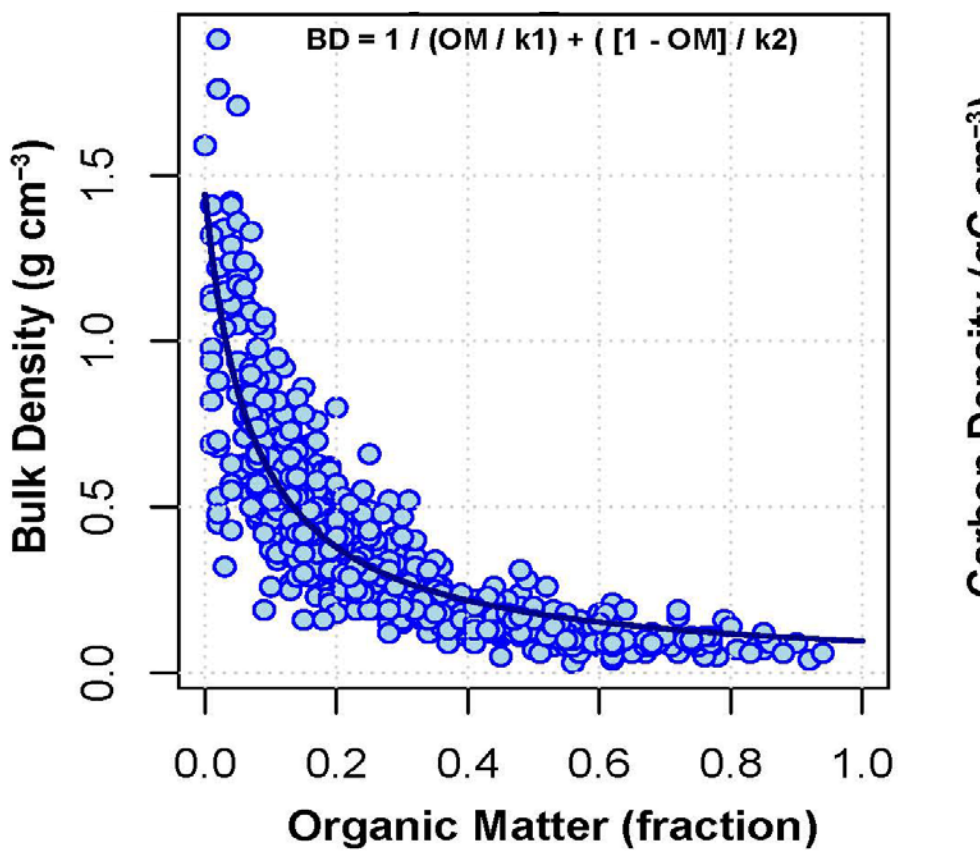
Soil C stock is 26.44 g C m^{-3}(SE=1,SD=14)

- No variation with site or depth
- Mixing model (Morris et al 2016)

Carbon Density

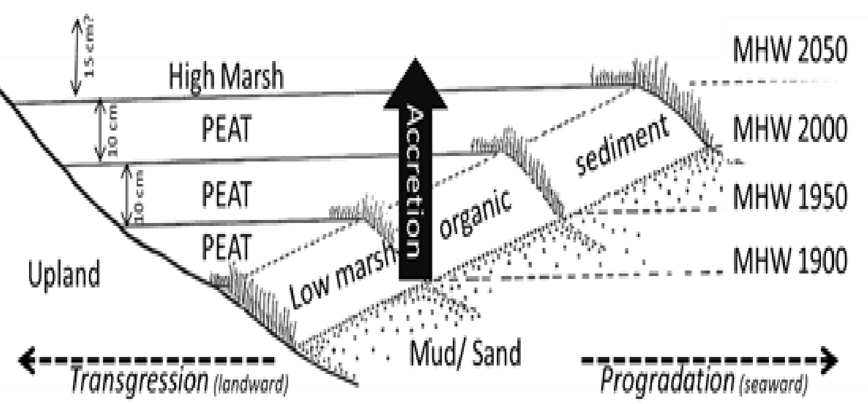


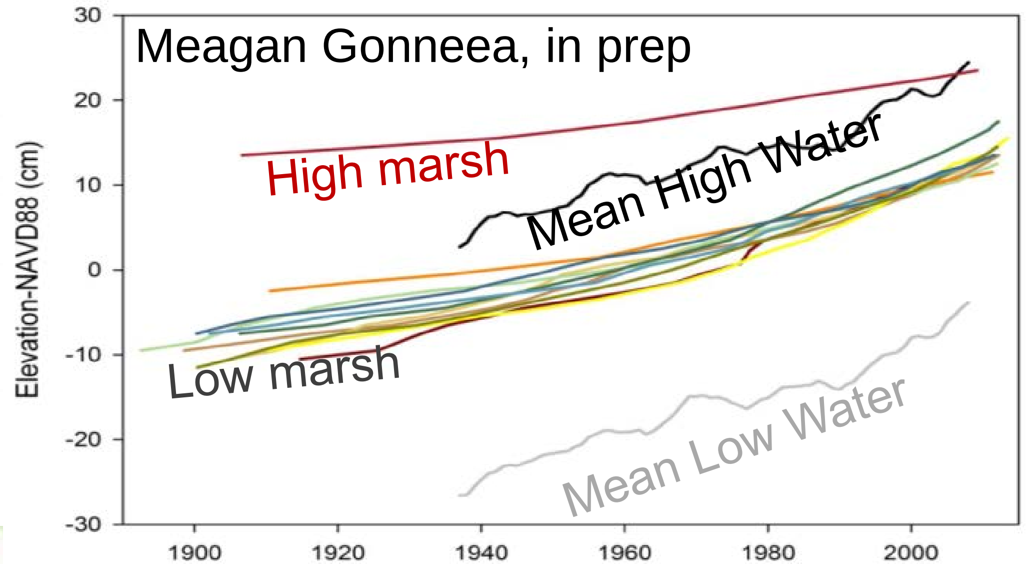
Bulk Density vs. Organic Matter



Soil Accretion = f (Relative SLR)

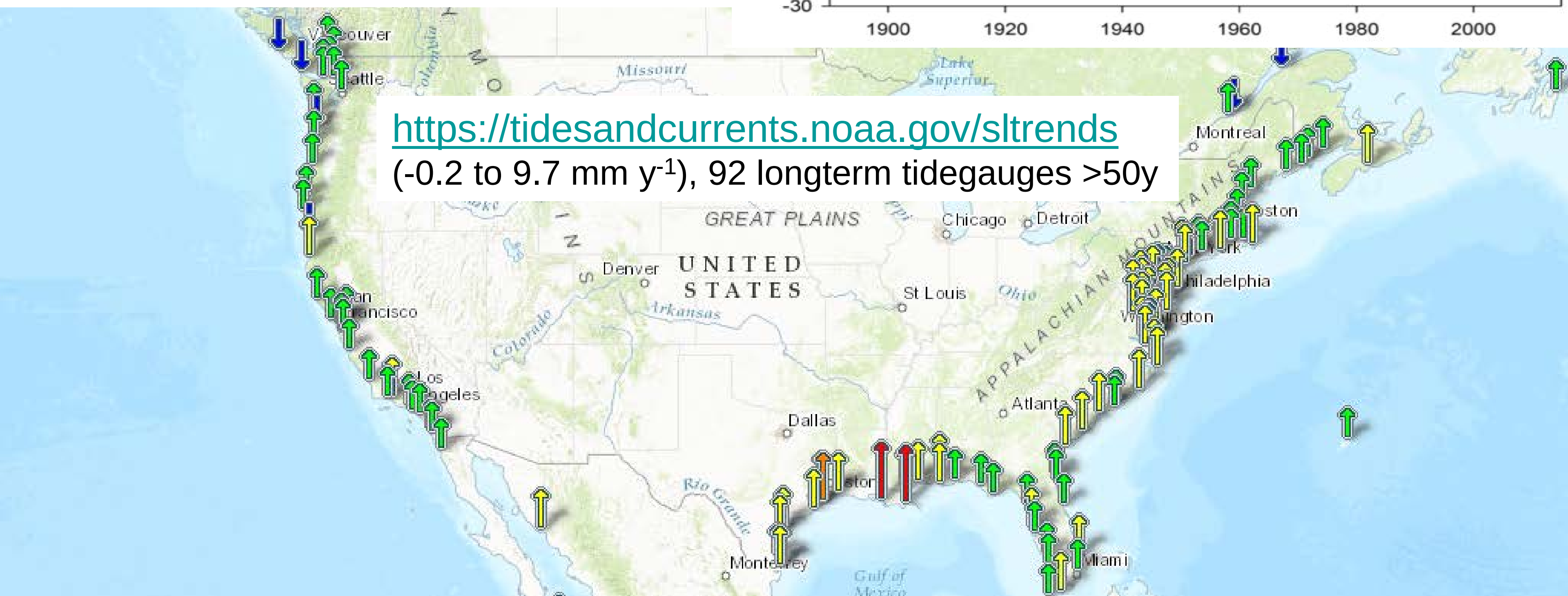
Redfield, 1965





https://tidesandcurrents.noaa.gov/sltrends

(-0.2 to 9.7 mm y^{-1}), 92 longterm tidegauges >50y



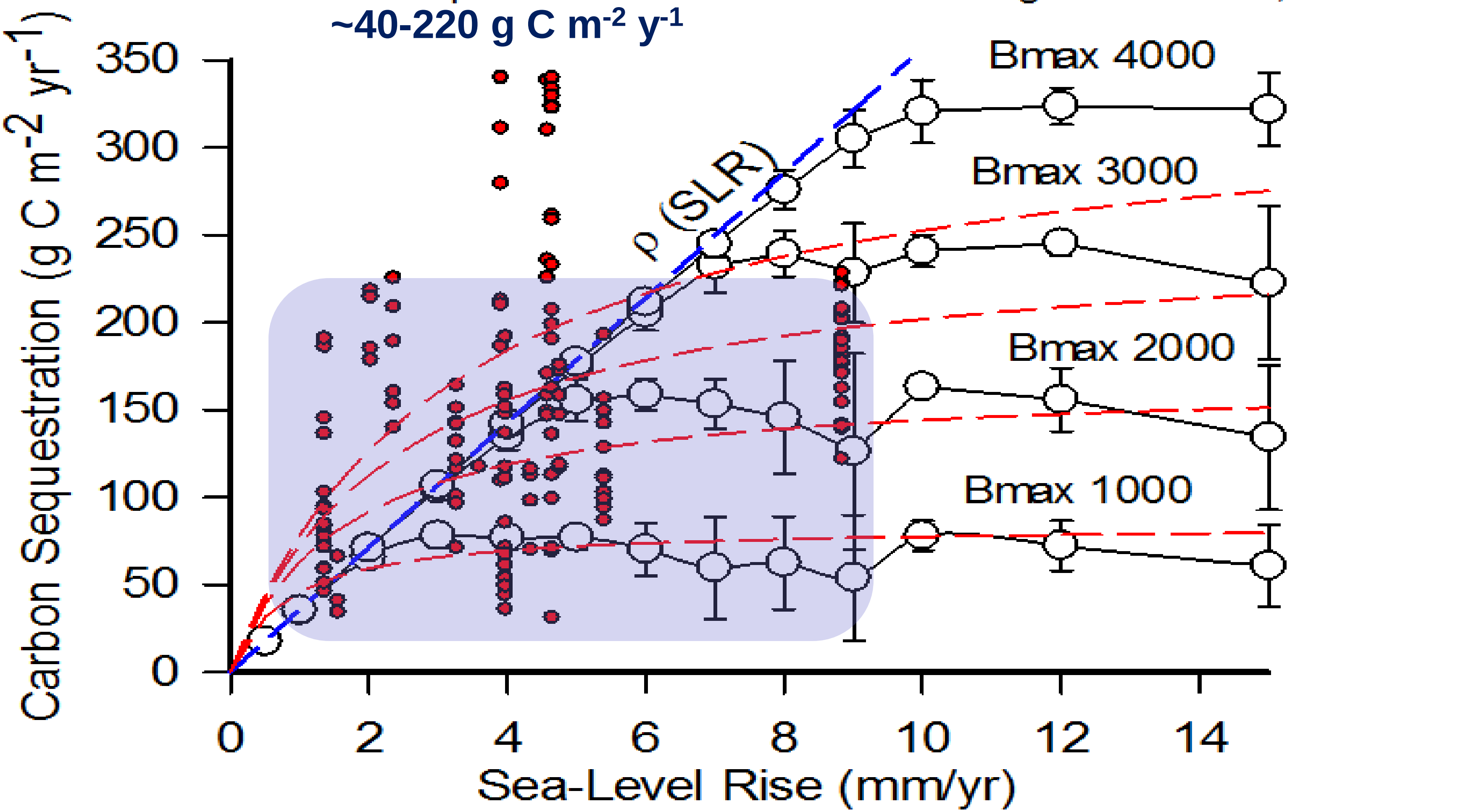
Modeled Soil C Sequestration:MEM

C Accretion = includes allochtonous and labile

C Sequestration = direct and longterm C sink

cquest=Bmax*0.084 * SLR/(SLR + ks*0.084*Bmax/(0.085*0.042*10000))

best fit of this equation to the MEM calculations gives ks=0.43, r^2=0.88

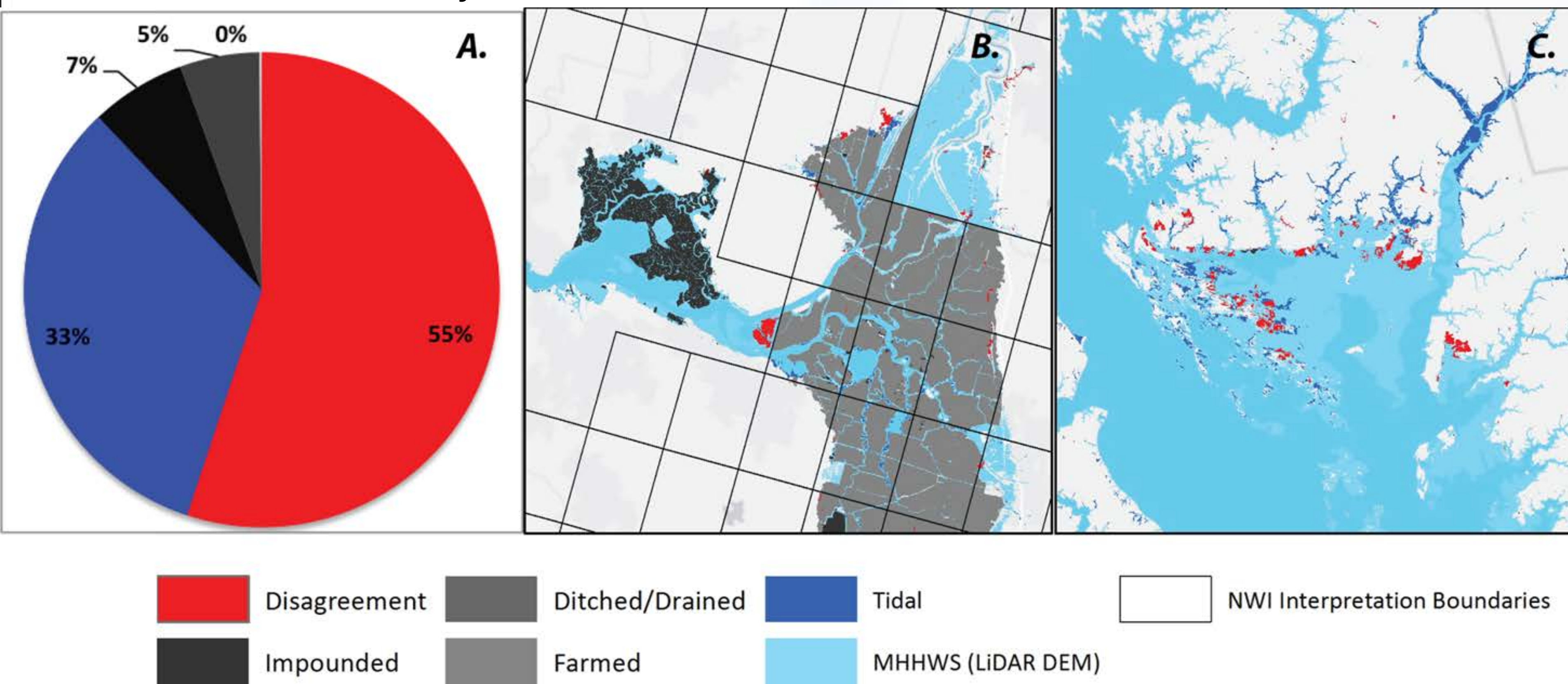


National maps = high uncertainty

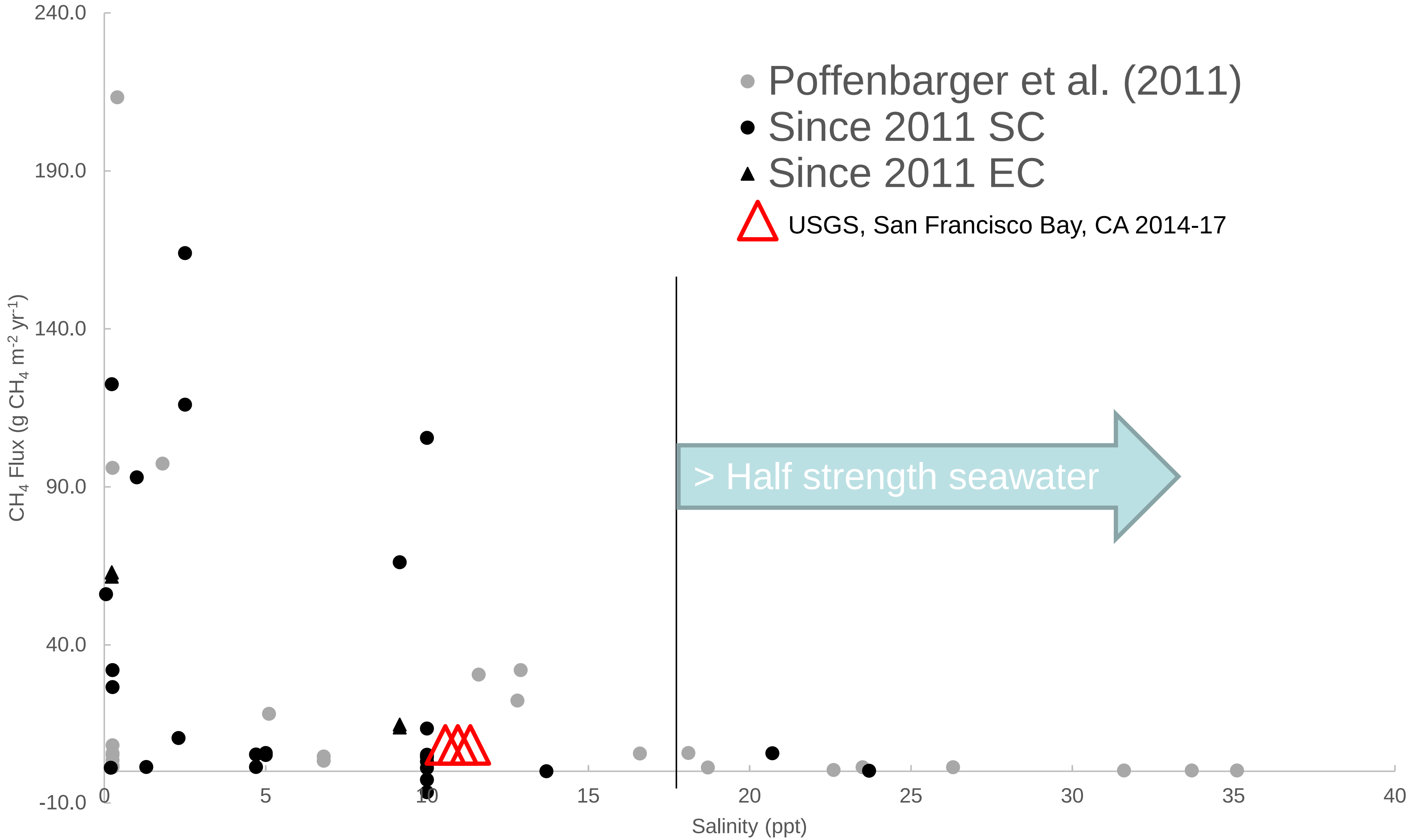
- **Tidal zone/connectivity**
- Salinity (fresh, mixed, saline)
- Elevation

e.g. NWI hydrology modifiers are not consistent with LiDAR or field observations

CONUS: +1M ha likely tidal California Delta: errors Chesapeake Bay: errors



Methane Flux = high uncertainty <18 ppt



BCMS: spatially explicit accuracy/precision

Soil C stock change (all LULCC)

Plant C stock change (aboveground only)

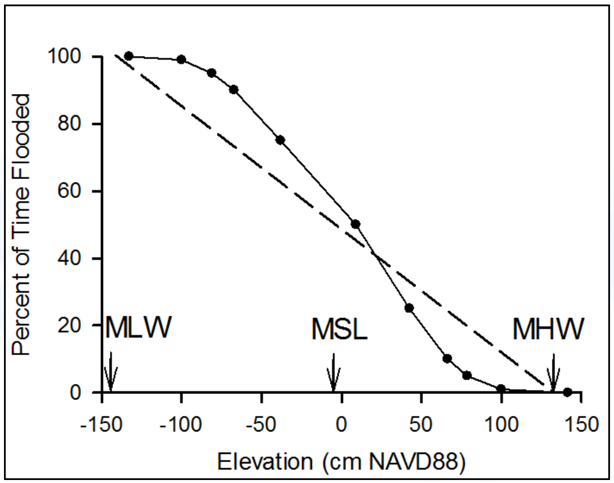
Methane flux change (CO_{2eq}, IPCC default)

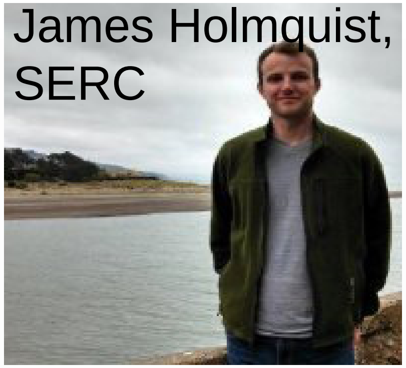
70% EEM-EEM	8% PEM-PEM	10% EFO-EFO	10% PFO-PFO	2% EEM-OW	1% PEM-EEM	1% PSS/FO-EEM
Mg CO_{2eq}/ha	Mg CO_{2eq}/ha	Mg CO_{2eq}/ha	Mg CO_{2eq}/ha	Mg CO_{2eq}/ha	Mg CO_{2eq}/ha	Mg CO_{2eq}/ha
-3.7	-3.7	-3.7	-3.7	+981	-3.7	-3.7
0	0	0	0	+7.4	0	+5
0	+3.9	0	+3.9	0	-3.9	-3.9

1. Biomass Stocks and Soil Stocks:
   - Regional variation is minor (Modeled default values biomass and soil)
   - Remaining variation is within watershed (salinity and relative elevation)
2. Accretion is difficult to model due to within-basin variability
3. Key uncertainties are tidal zone map and methane variability

Future – *elevation is a critical need*

Relevant elevation (cm scale) by merging remotely sensed (LiDAR, spectral) and ground data is a critical modeling and monitoring need for C fluxes.





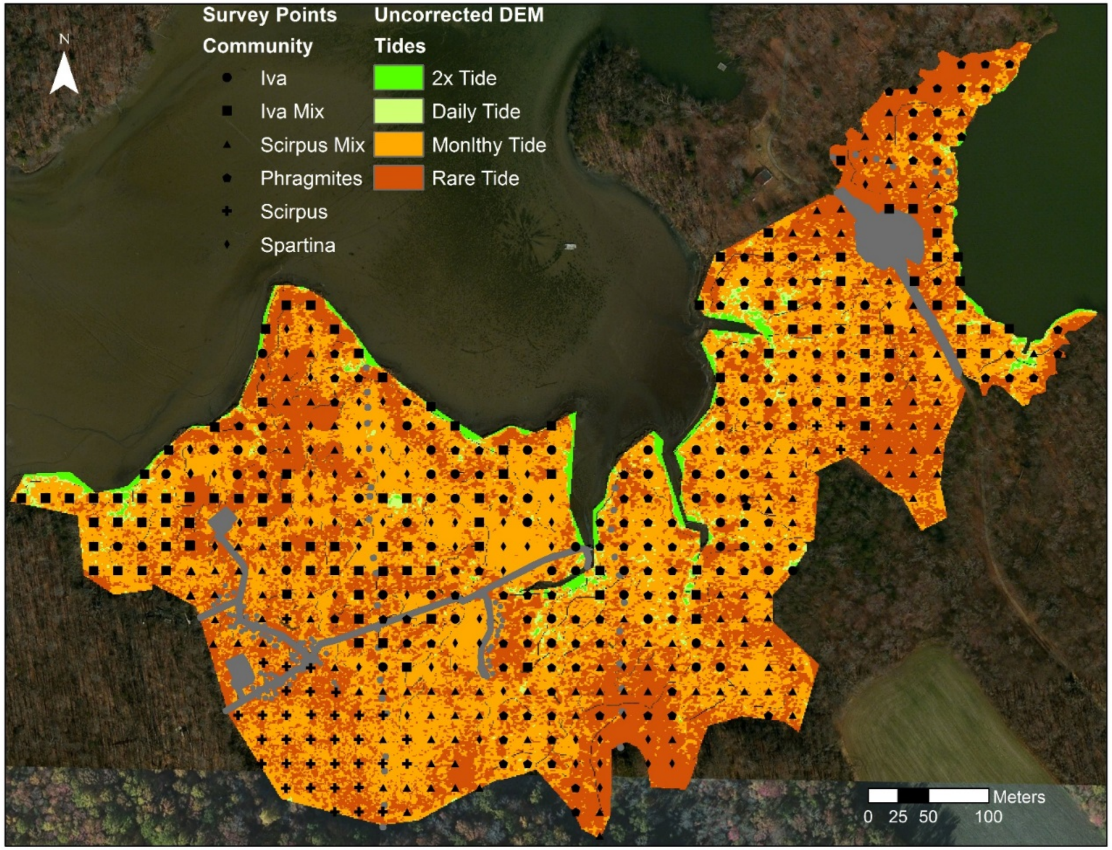
Tidal DEMs = avg +22cm Bias

Bias Overwhelmingly Positive: Marsh DEMs need vegetation correction
Overestimating elevation leads to overestimating resilience

Site	Cit	n	RMSE	ME
GCREW - before	Holmquist, Reiera, et al., In Prep	413		0.192
Grays Harbor	Buffington et al., 2016	1166	0.466	0.419
Willapa	Buffington et al., 2016	420	0.392	0.382
Siletz	Buffington et al., 2016	1113	0.304	0.269
Bull Island	Buffington et al., 2016	1166	0.145	0.078
Bandon	Buffington et al., 2016	1495	0.118	0.016
Petaluma	Buffington et al., 2016	623	0.289	0.282
Black John	Buffington et al., 2016	203	0.278	0.264
San Pablo	Buffington et al., 2016	374	0.265	0.253
Fagan	Buffington et al., 2016	578	0.256	0.242
Coon Island	Buffington et al., 2016	728	0.273	0.26
China Camp	Buffington et al., 2016	697	0.233	0.228
Corte Madera	Buffington et al., 2016	399	0.182	0.228
Morro	Buffington et al., 2016	2247	0.109	0.082
Mugu	Buffington et al., 2016	1465	0.155	0.154
Seal Beach	Buffington et al., 2016	3208	0.168	0.147
Newport	Buffington et al., 2016	962	0.183	0.14
Tijuana	Buffington et al., 2016	896	0.113	0.084
Sapelo Island - Total	Hladik and Alber, 2012	1380	0.18	0.1
lower Apalachicola River Marsh	Mederios et al., 2015	229	0.65	0.61
	SUM	19762	Avg:	0.2215

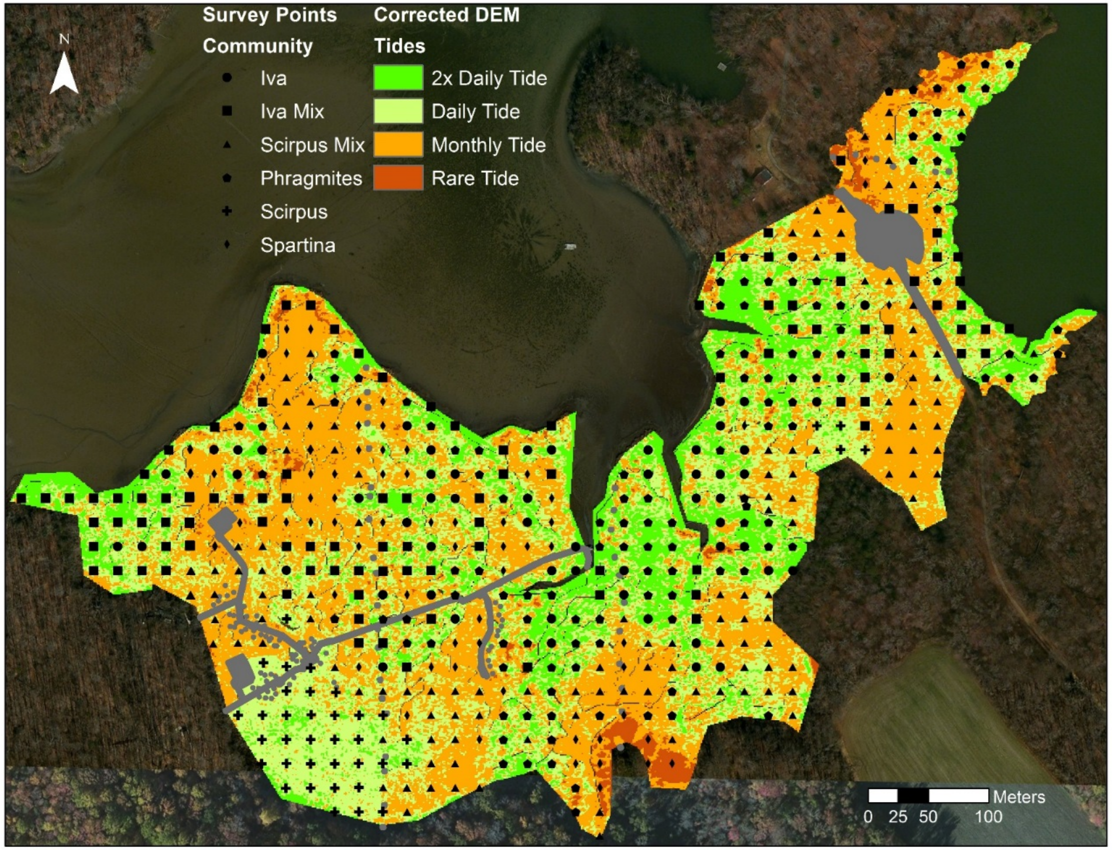
Future – elevation is a critical need

2011 Anne Arundel County DEM (MD)



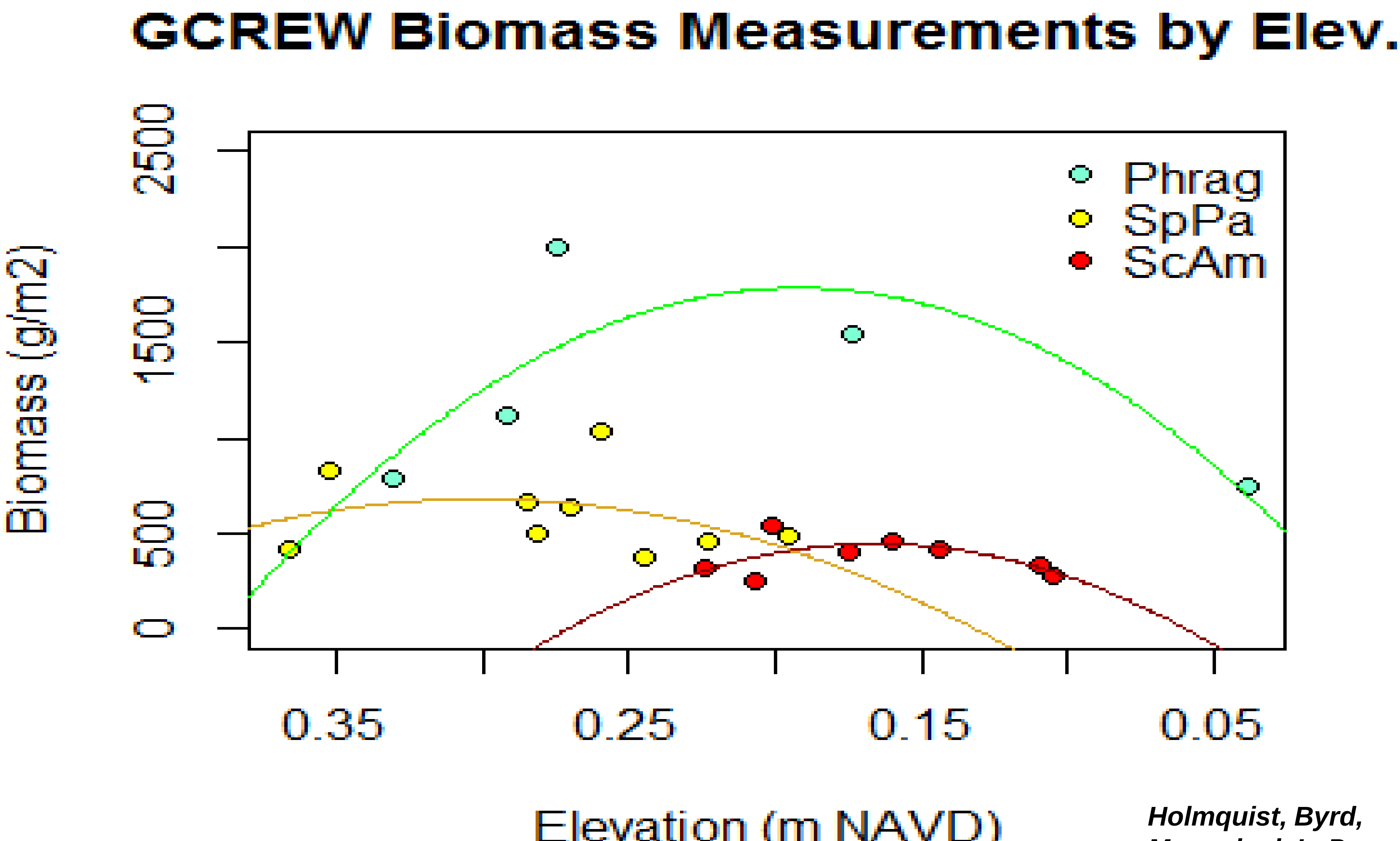
Future – elevation is a critical need

Veg-Corrected 2011 Anne Arundel County DEM



Holmquist, Riera et al., In Prep.

MEM validation and sensitivity

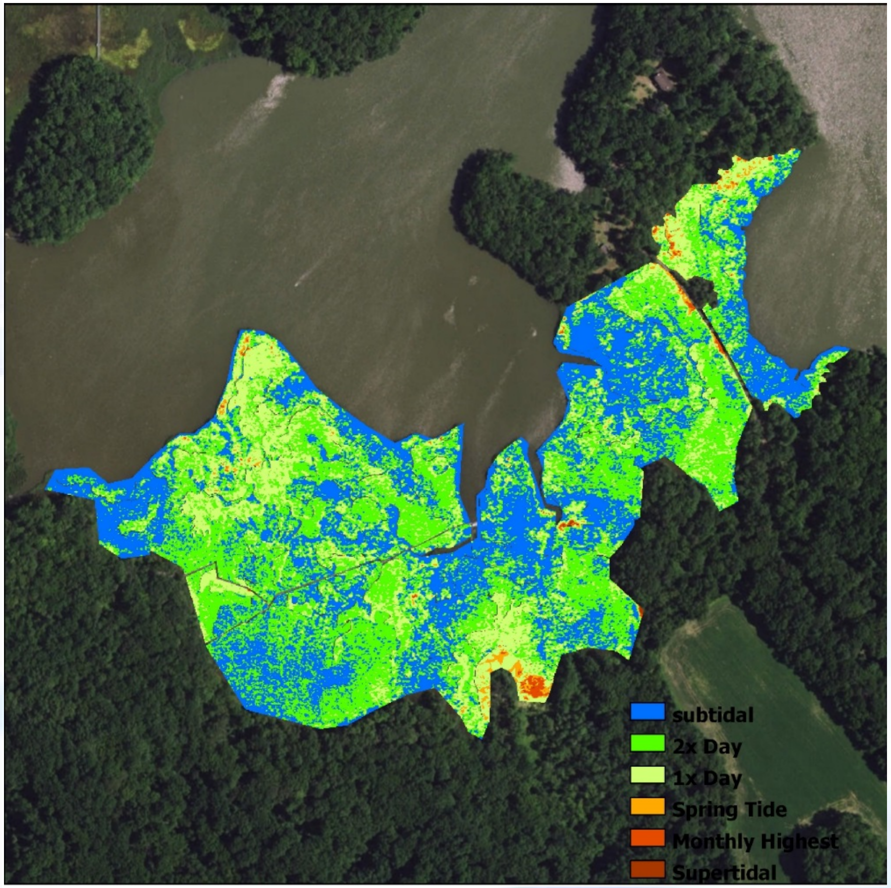


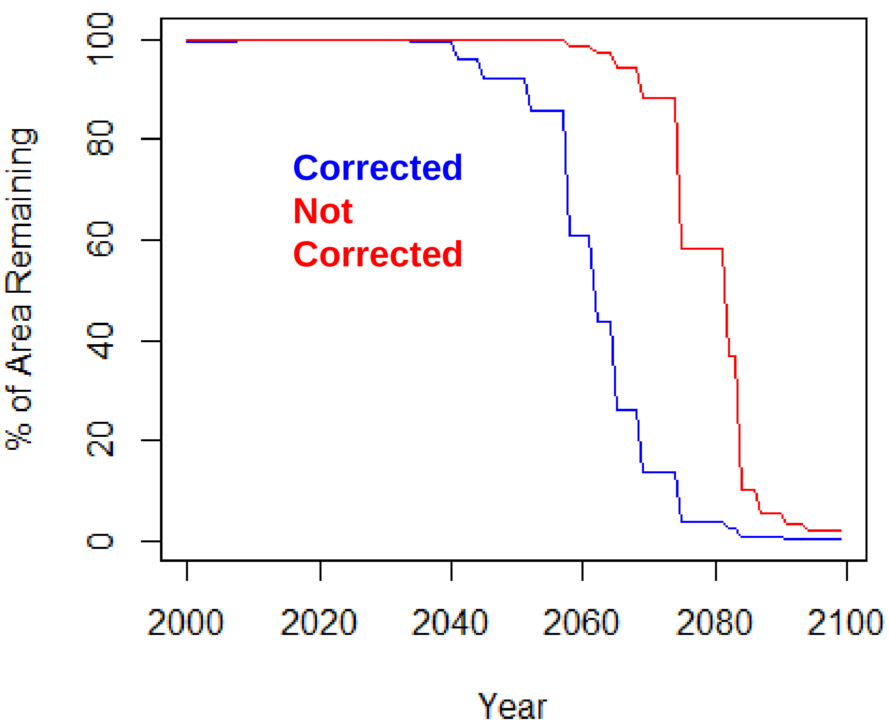
Holmquist, Byrd, Megonigal, In Prep.

Highly sensitive to initial elevation

Corrected

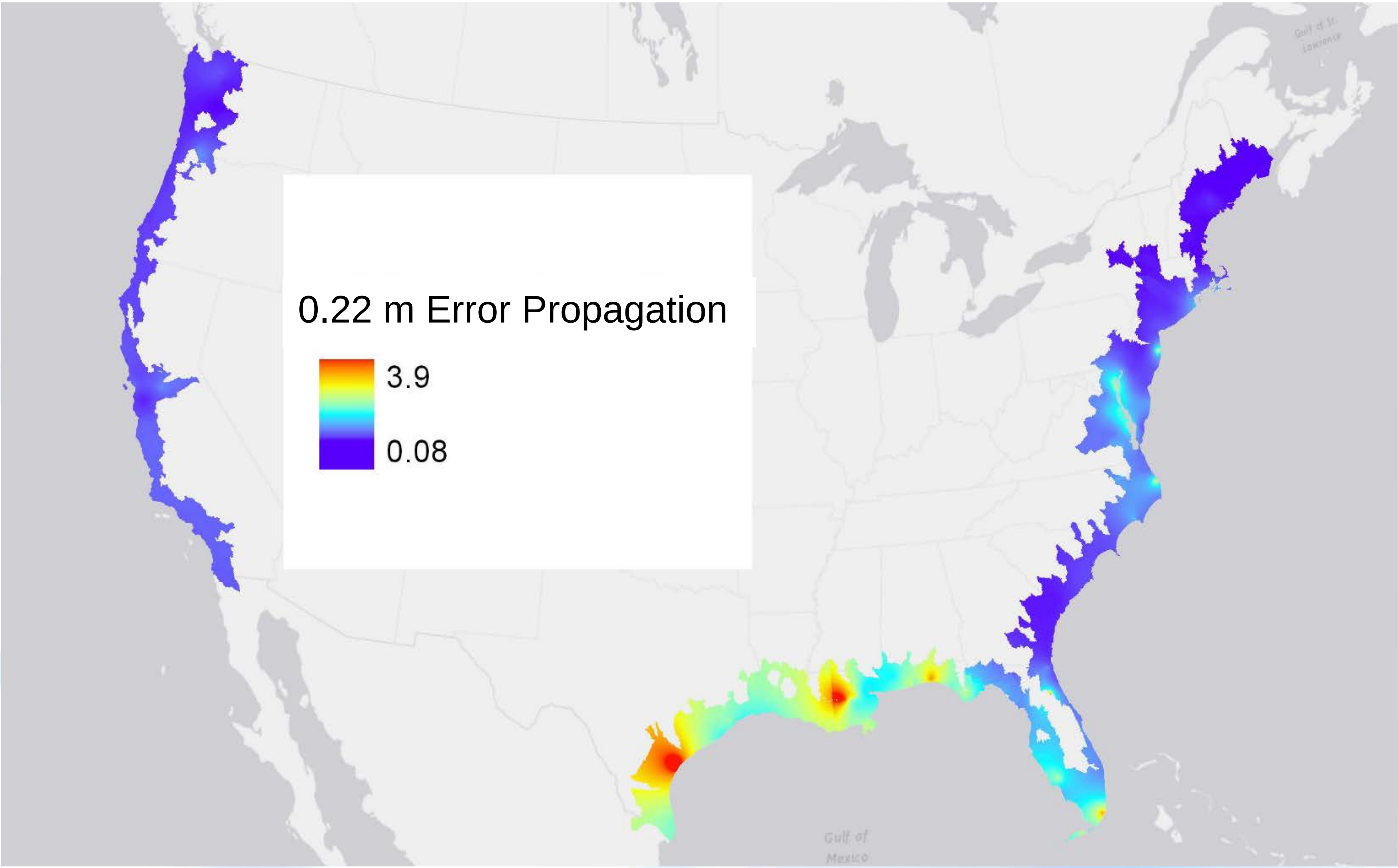
Not Corrected





Holmquist, Riera et al., In Prep.

Microtidal (<30cm) = most sensitive



BCMS – Products coming in 2017

Final Report – November 2017, CMS Science Team Meeting

Publications acknowledging CMS contribution:
Morris et al (2016, Earths Future)
Hinson et al (accepted, Global Change Biology)
EPA GHG Inventory 1990-2015
Windham-Myers, Troxler and Crooks: A Blue Carbon Primer (CRC Press, in review)

Pending Publications:
Byrd et al (in review, Remote Sensing and the Environment)

Gonneea and Kroeger (in revision, Estuaries and Coasts)
Holmquist et al (in review, Nature Communications)
Drexler, Judith (in prep, The approaching obsolescence of 137 Cs as a means of dating)

Holmquist et al (in prep, Conservative estimates of 1m depth CONUS Wetland C stocks)

Windham-Myers et al, SOCCR-2 Tidal Wetlands and Estuaries, Chapter 15 (in review)
Crooks et al (in review, Nature Climate Change)

By 11/17: Price of precision in tidal wetlands: a sensitivity analysis of 18 model inputs