DELAWARE WETLAND CONFERENCE 2016
RIVERFRONT, WILMINGTON
DELAWARE | February 3, 2016

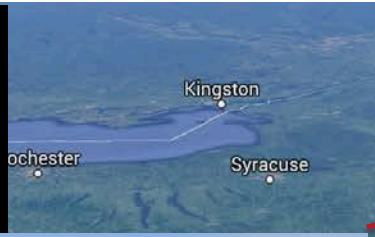
# AN OVERVIEW OF THE NFWF POST-SANDY BOMBAY HOOK PROJECT: NUMERICAL MODELING & IN-SITU MEASUREMENTS

ALI ABDOLALI, JIM KIRBY, FENGYAN SHI, GUOXIANG WU, CHRIS SOMMERFIELD, CONOR MCDOWELL

Center for Applied Coastal Research (CACR)
The College of Earth, Ocean, and Environment (CEOE)
UNIVERSITY OF DELAWARE

abdll@udel.edu

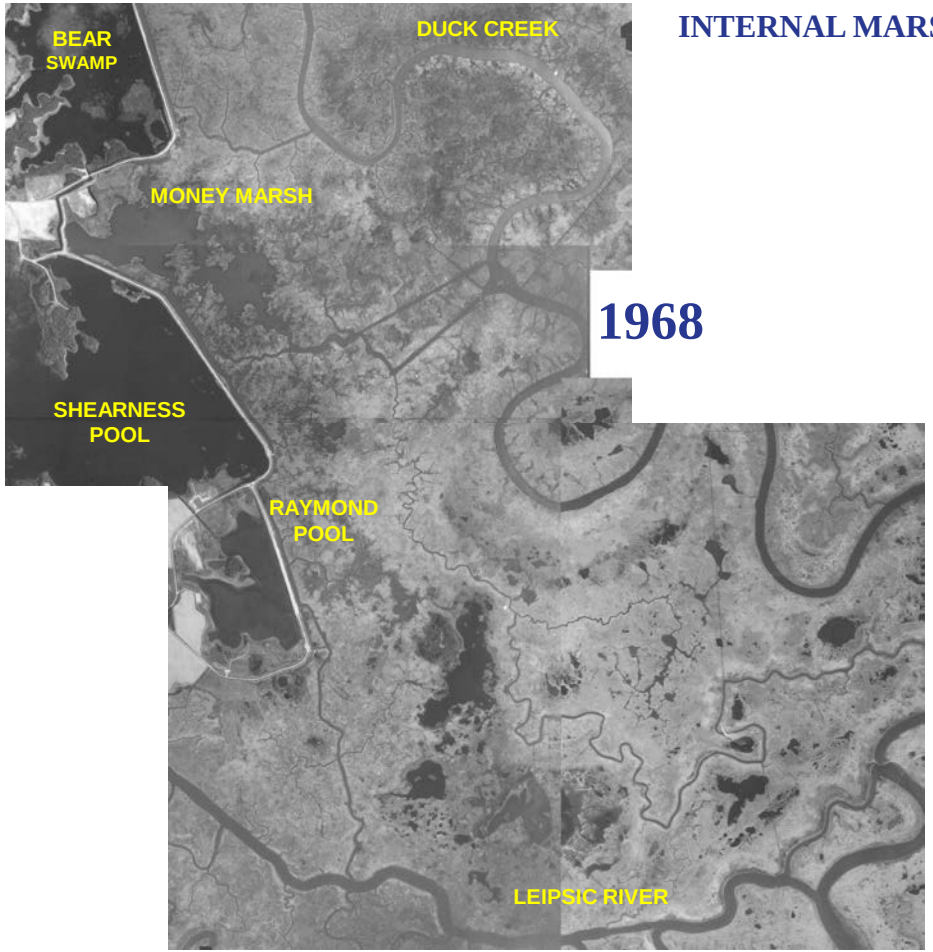
# MOTIVATIONS



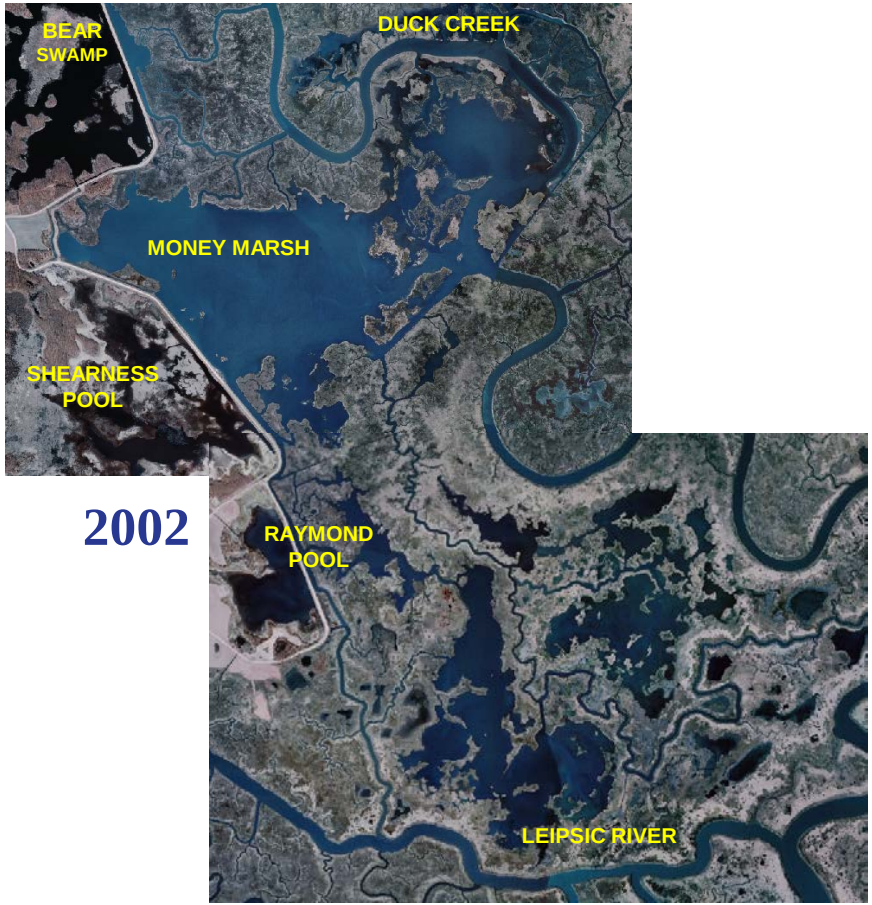

## Bay Side Erosion

## BAYSHORE EROSION AT BOMBAY HOOK NWR

# INTERNAL MARSH LOSS AT BOMBAY HOOK NWR




1968



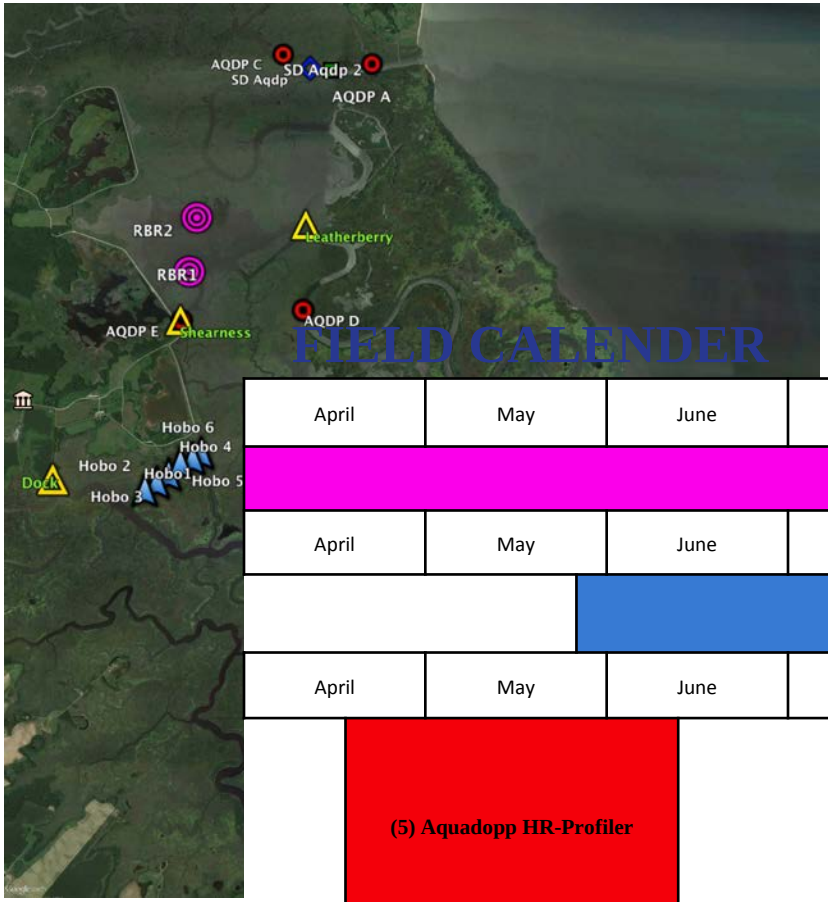

2002

# Overview of project goals and plans

- ✓ Conduct a comprehensive numerical and field investigation to understand:
- o The dominant hydrodynamics for present marsh conditions.
- o Sedimentation rates and marsh platform response to sea level rise.
- o Effects of past marsh alterations on marsh accretion/deterioration (i.e. Sluice Ditch Construction in 1800's).
- o Wetland response to extreme conditions (i.e. storm surges, hurricanes, etc.)
- o Long term changes due to sea-level rise, change in sediment supply, channel widening/deepening, wind waves, marsh subsidence, etc.

- ✓ **Data collection**
- Background: DNREC tide gages, LIDAR data sets
- Surveying:
  - channel bathymetry and boundary mapping: McDowell's Poster
  - RTK ground truth evaluation of 2011, 2014 LIDAR and Stammermann & Piasecki DEM used for present model grid
- Current profilers: deployment history, goals of each deployment
- HOBO's: inundation of marsh platform
- RBR fast pressure gauges: waves in Money Marsh, potential for shoreline erosion from locally generated wind waves

# FIELD MEASUREMENTS




- (11) Aquadopp HR-Profiler (2 MHz)
  - Apr 16 - Jun 11
  - Aug 19 - Sep 22
  - Nov 24 - Dec 31, 2015
- (6) Hobo Water Level Data Logger (0.003 Hz)
  - May 27- Dec 31, 2015
- (2) RBR Solo Depth/Pressure Logger (16 Hz)
  - March 31- Dec 31, 2015
- (4) Tide Gauge (0.001 Hz)

## FIELD CALENDER

| April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|
| (2) RBR Solo Depth/Pressure Logger (16 Hz) | | | | | | | | |
| April | May | June | July | August | September | October | November | December |
| | | (6) Hobo Water Level Data Logger (0.003 Hz) | | | | | | |
| April | May | June | July | August | September | October | November | December |
| | (5) Aquadopp HR-Profiler | | | | (3) Aquadopp HR-Profiler | | | (3) Aquadopp HR-Profiler |

# TIDE GAUGE ANALYSIS (DNREC 2008-present)

## Dock Site

| tide | period (hr) | amp (m) | Φ |
|---|---|---|---|
| *M2 | 12:25 | 0.6837 | 309.58 |
| *N2 | 12:39 | 0.1243 | 72.26 |
| *K1 | 23:56 | 0.0941 | 66.87 |
| *M4 | 06:12 | 0.0874 | 105.84 |

## Navigation Light

| tide | period (hr) | amp (m) | Φ |
|---|---|---|---|
| *M2 | 12:25 | 0.7937 | 285.42 |
| *N2 | 12:39 | 0.1571 | 40.63 |
| *S2 | 12:00 | 0.117 | 319.04 |
| *K1 | 23:56 | 0.0976 | 37.49 |

## Shearness Gate

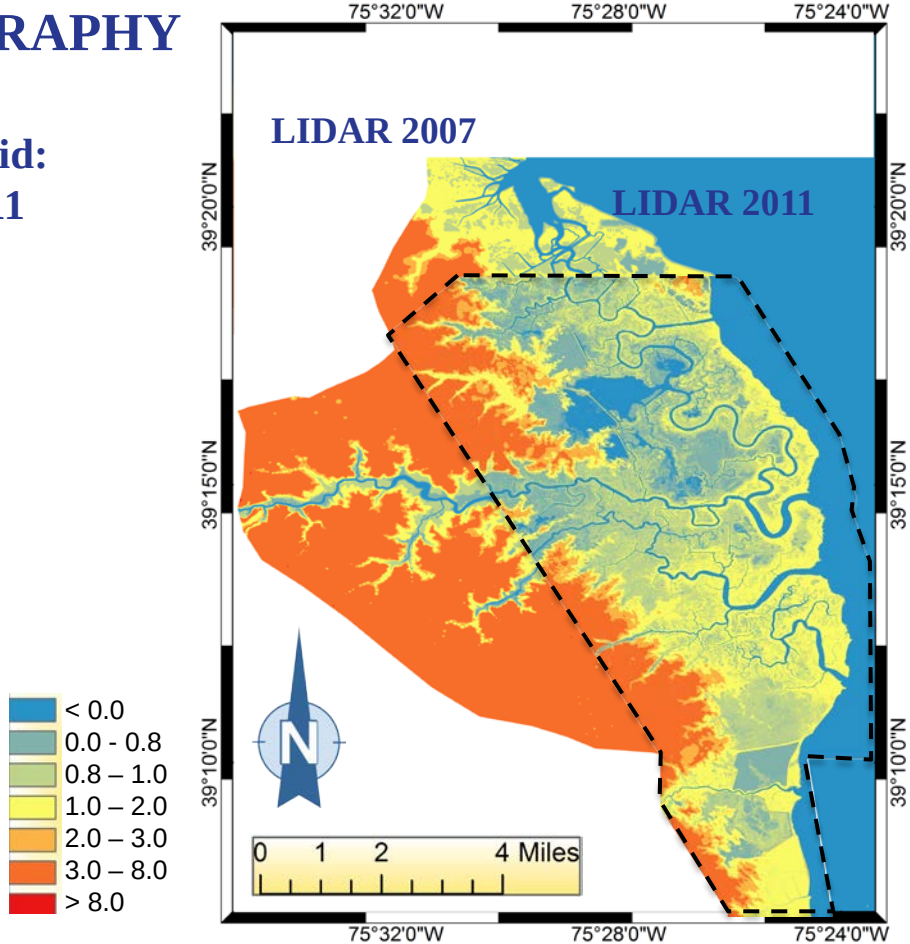
| tide | period (hr) | amp (m) | Φ |
|---|---|---|---|
| *M2 | 12:25 | 0.6927 | 316.47 |
| *N2 | 12:39 | 0.1257 | 80.17 |
| *K1 | 23:56 | 0.0926 | 68.38 |
| *S2 | 12:00 | 0.086 | 7.13 |

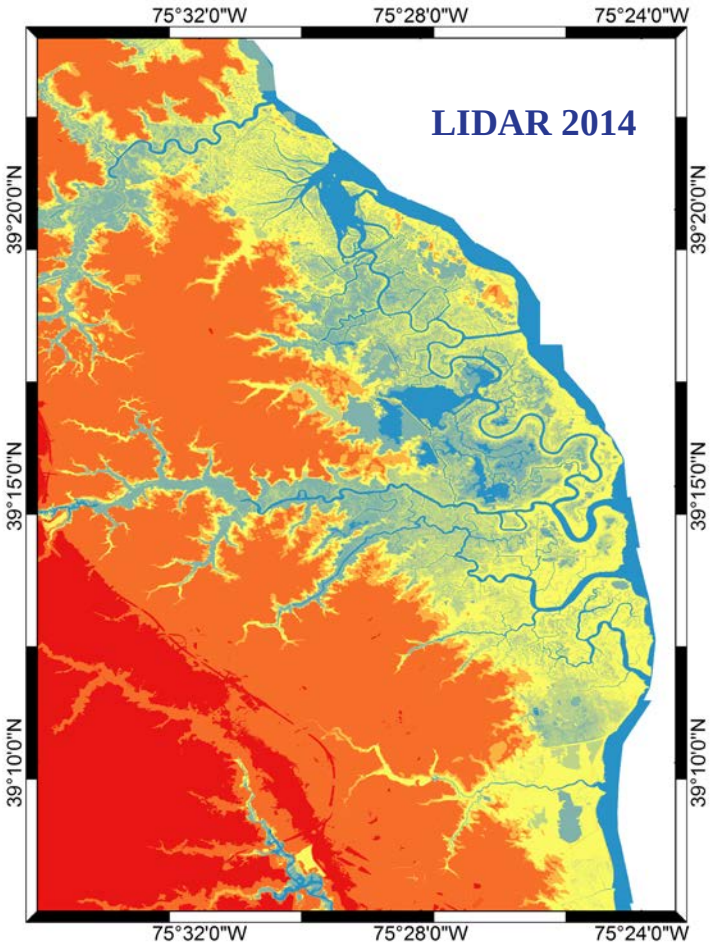
## Leatherbery Pool

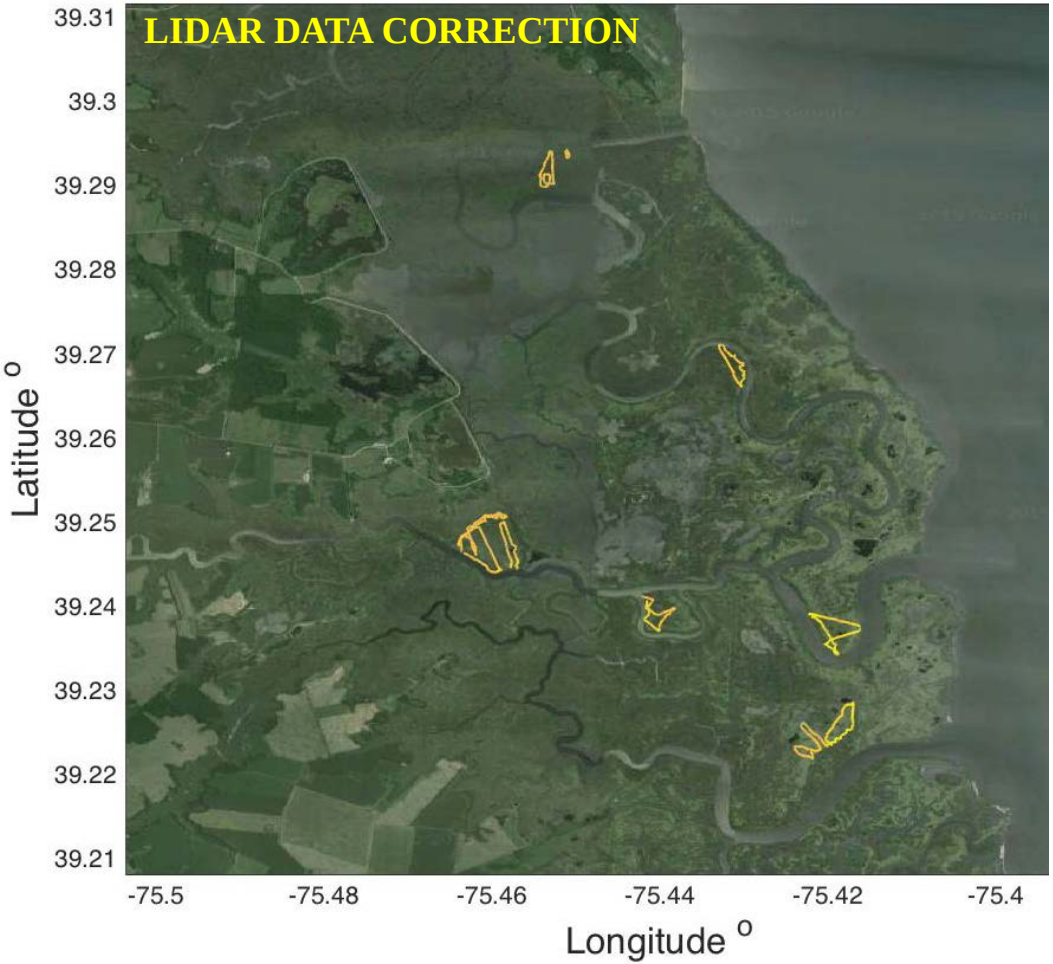
| tide | period (hr) | amp (m) | Φ |
|---|---|---|---|
| *M2 | 12:25 | 0.7757 | 310.34 |
| *N2 | 12:39 | 0.1473 | 72.01 |
| *S2 | 12:00 | 0.1034 | 355.81 |
| *K1 | 23:56 | 0.0991 | 62.73 |

# TOPOGRAPHY

**Present Grid:**
**2007 & 2011**

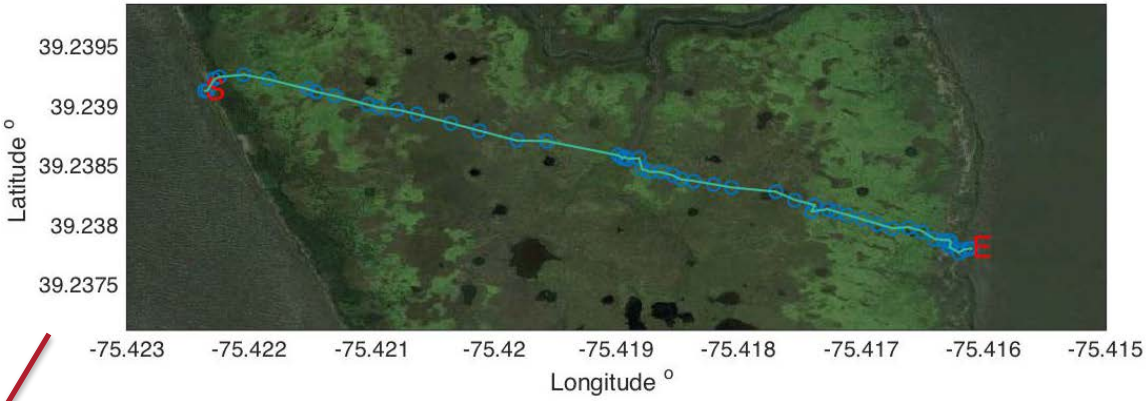


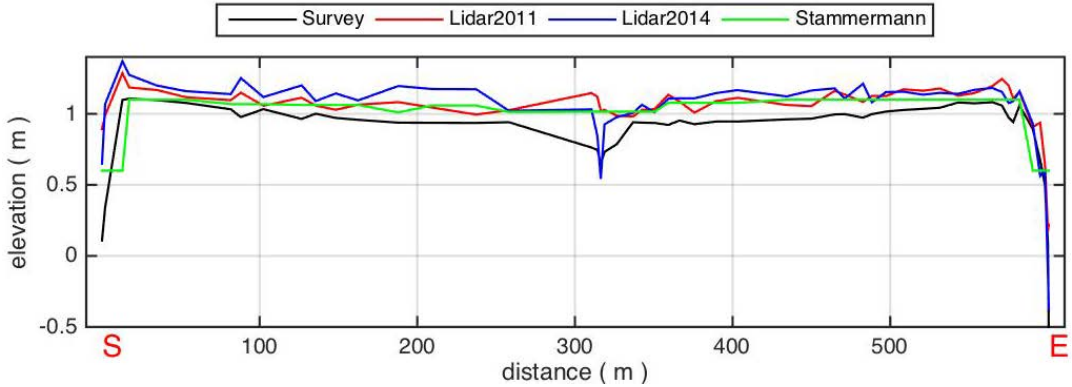






# 1300 points collected during a 7 day ground truth survey

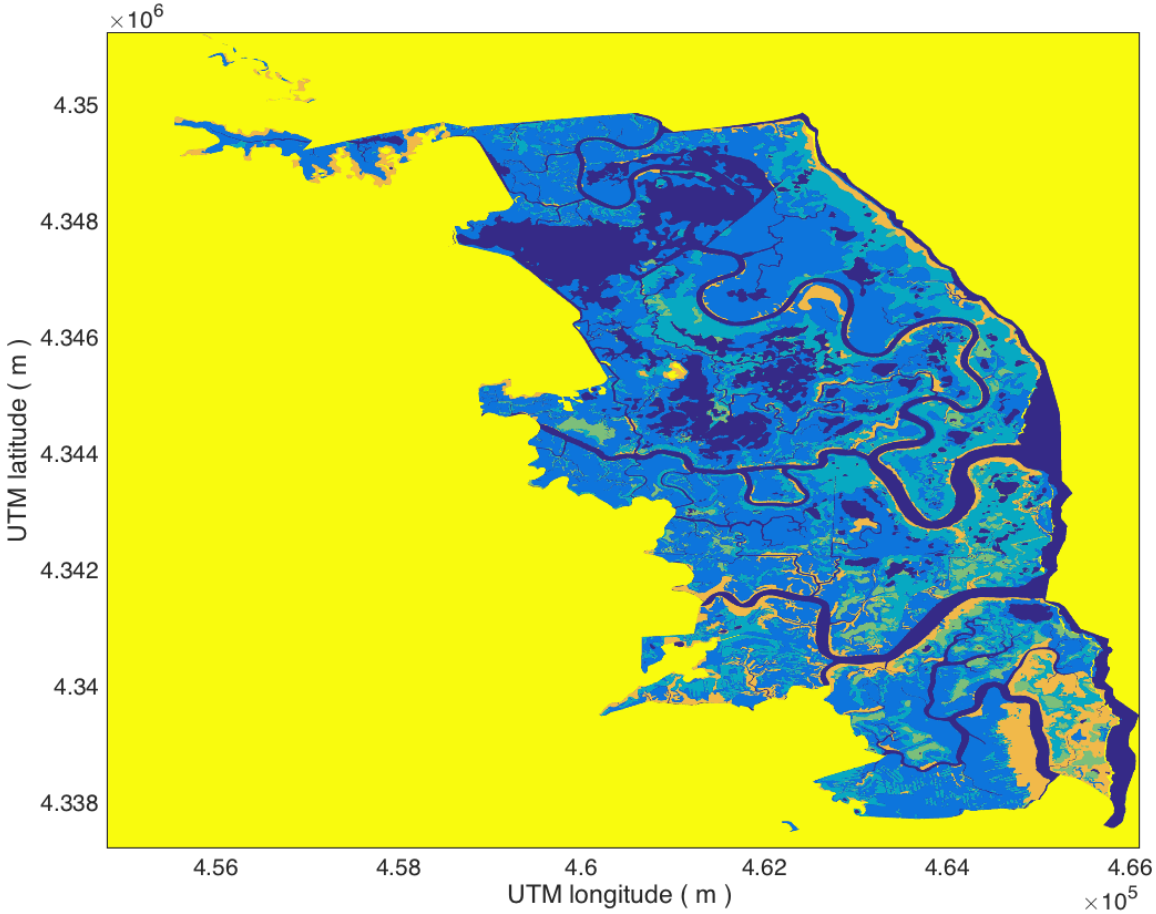
special thanks to NWS


39.2395
39.239
39.2385
39.238
39.2375
Latitude °
S
E
-75.423
-75.422
-75.421
-75.42
-75.419
-75.418
-75.417
-75.416
-75.415
Longitude °

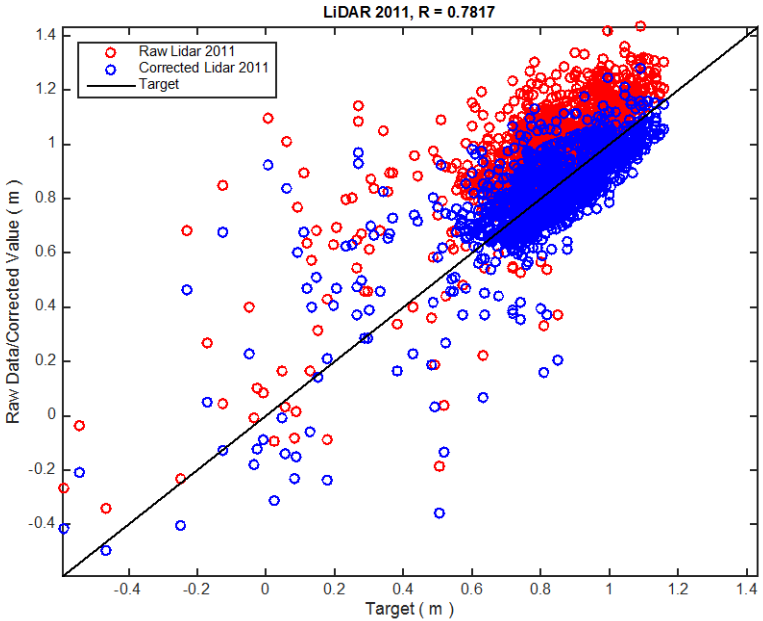

Survey
Lidar2011
Lidar2014
Stammermann
elevation ( m )
1
0.5
0
-0.5
S
100
200
300
400
500
E
distance ( m )

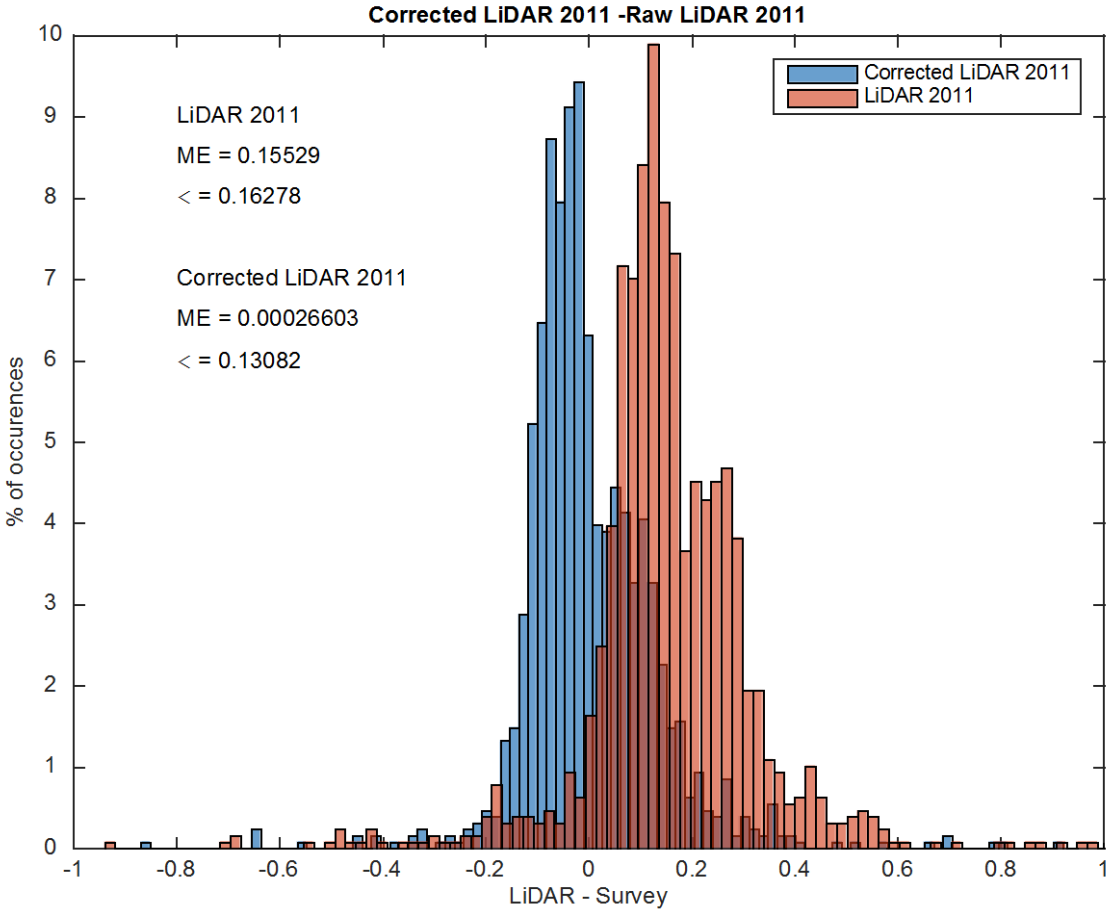
# VEGETATION MAP

| Type | Percentage % |
|---|---|
| Low Salt Marsh | 30.96 |
| High Salt Marsh | 15.15 |
| Water | 18.21 |
| Reed Tidal Marsh | 6.08 |
| Scrub/Shrub Wetland | 2.48 |
| Others | 27.13 |

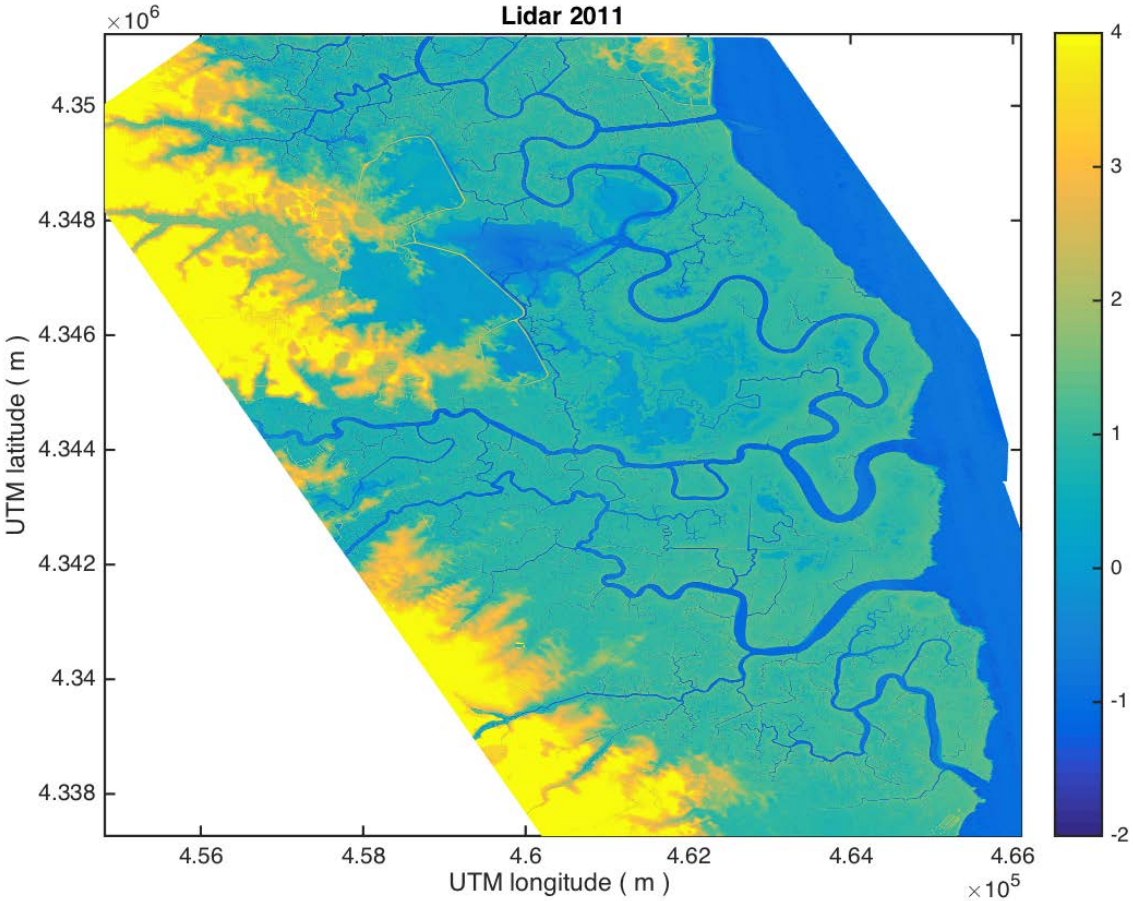


# LiDAR 2011

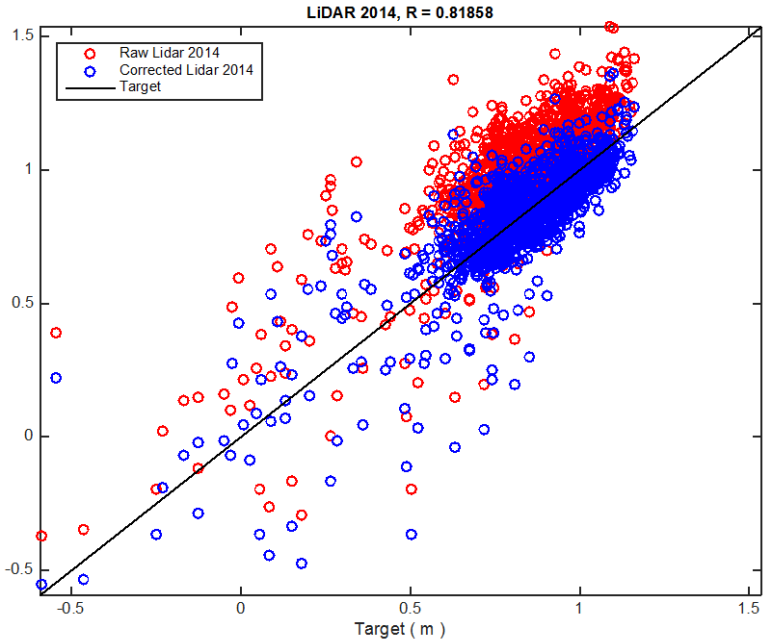

LiDAR 2011, R = 0.7817
Raw Lidar 2011
Corrected Lidar 2011
Target
Raw Data/Corrected Value ( m )
Target ( m )

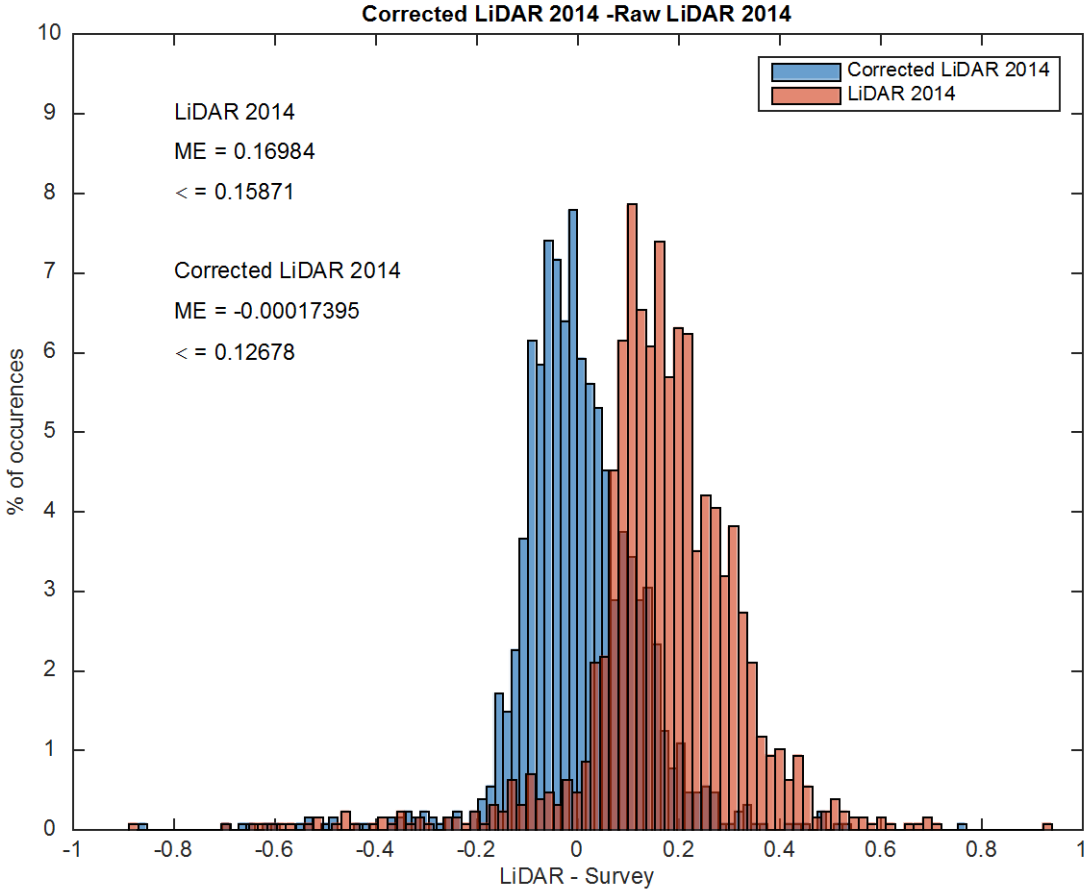

Corrected LiDAR 2011 -Raw LiDAR 2011
Corrected LiDAR 2011
LiDAR 2011
LiDAR 2011
ME = 0.15529
< = 0.16278
Corrected LiDAR 2011
ME = 0.00026603
< = 0.13082
% of occurences
LiDAR - Survey

| Type | Number | Correction (m) |
|---|---|---|
| Berm | 69 | 0.0948 |
| Water | 60 | 0.1125 |
| Low Salt Marsh | 639 | 0.1719 |
| High Salt Marsh | 337 | 0.1530 |
| Scrub/Shrub Wetland | 72 | 0.1551 |
| Reed Tidal Marsh | 106 | 0.2216 |
| NA | 1283 | 0.1542 |

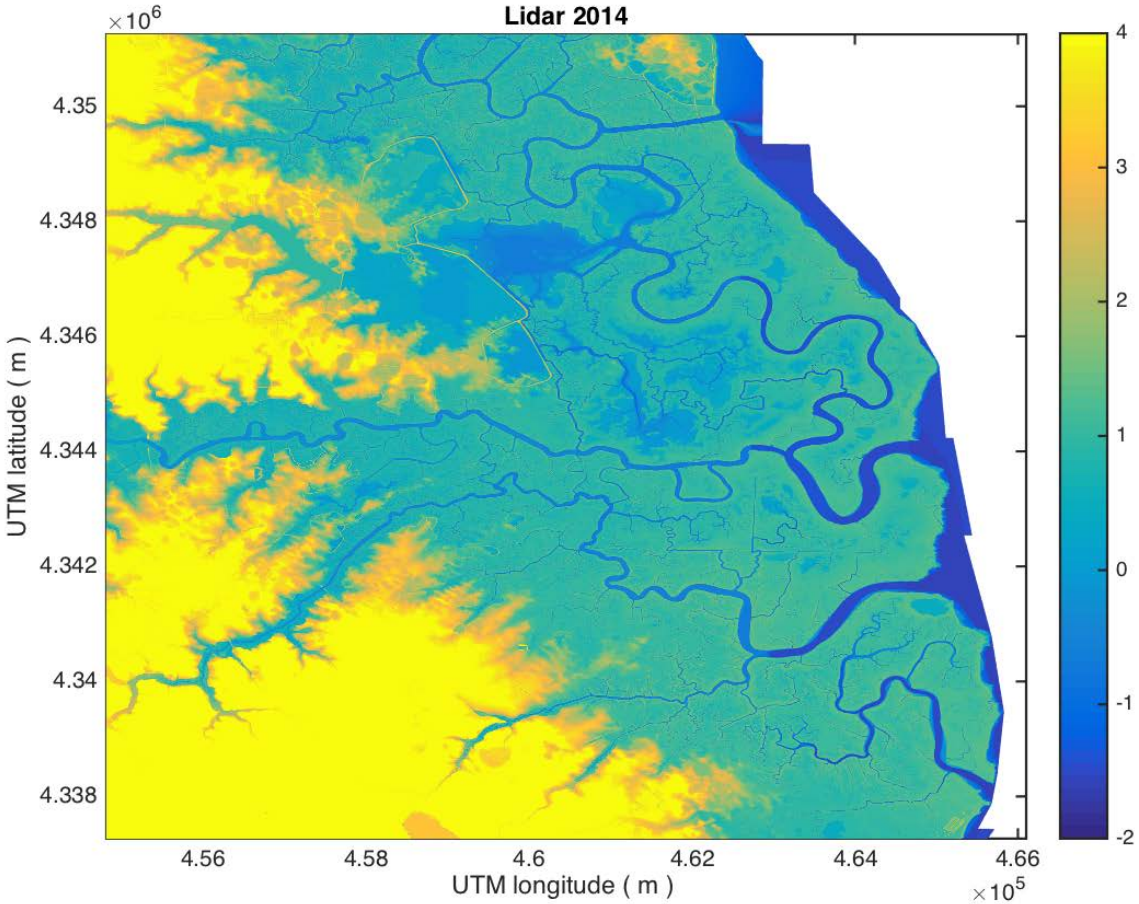


# LiDAR 2014


LiDAR 2014, R = 0.81858
Raw Lidar 2014
Corrected Lidar 2014
Target
1.5
1
0.5
0
-0.5
-0.5
0
0.5
1
1.5
Target ( m )

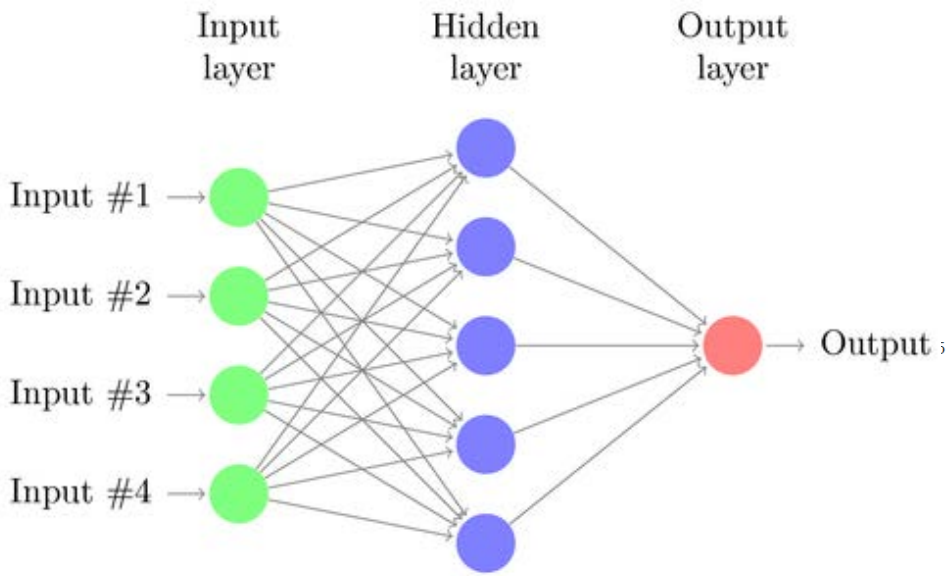

Corrected LiDAR 2014 -Raw LiDAR 2014
Corrected LiDAR 2014
LiDAR 2014
LiDAR 2014
ME = 0.16984
< = 0.15871
Corrected LiDAR 2014
ME = -0.00017395
< = 0.12678
% of occurences
10
9
8
7
6
5
4
3
2
1
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
LiDAR - Survey

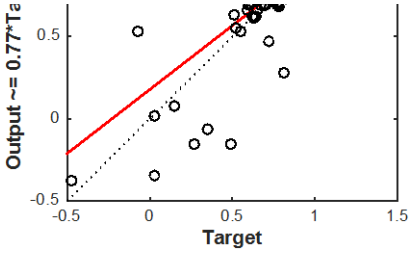
| Type | Number | Correction (m) |
|---|---|---|
| Berm | 69 | 0.1073 |
| Water | 60 | 0.1345 |
| Low Salt Marsh | 639 | 0.1694 |
| High Salt Marsh | 337 | 0.1853 |
| Scrub/Shrub Wetland | 72 | 0.2171 |
| Reed Tidal Marsh | 106 | 0.2062 |
| NA | 1283 | 0.1696 |

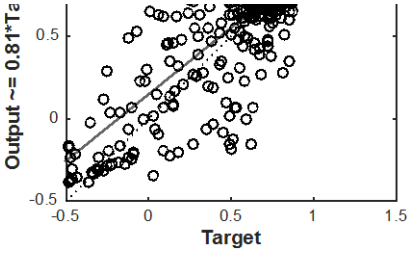


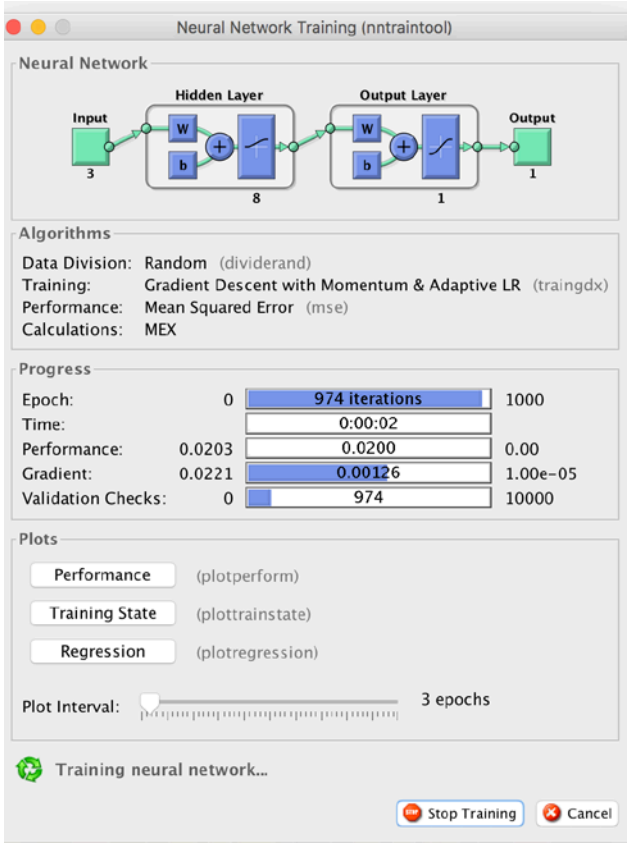
# Artificial Neural Network (ANN)

# Elevation = *f* (Vegatation Type, LiDAR Layers)

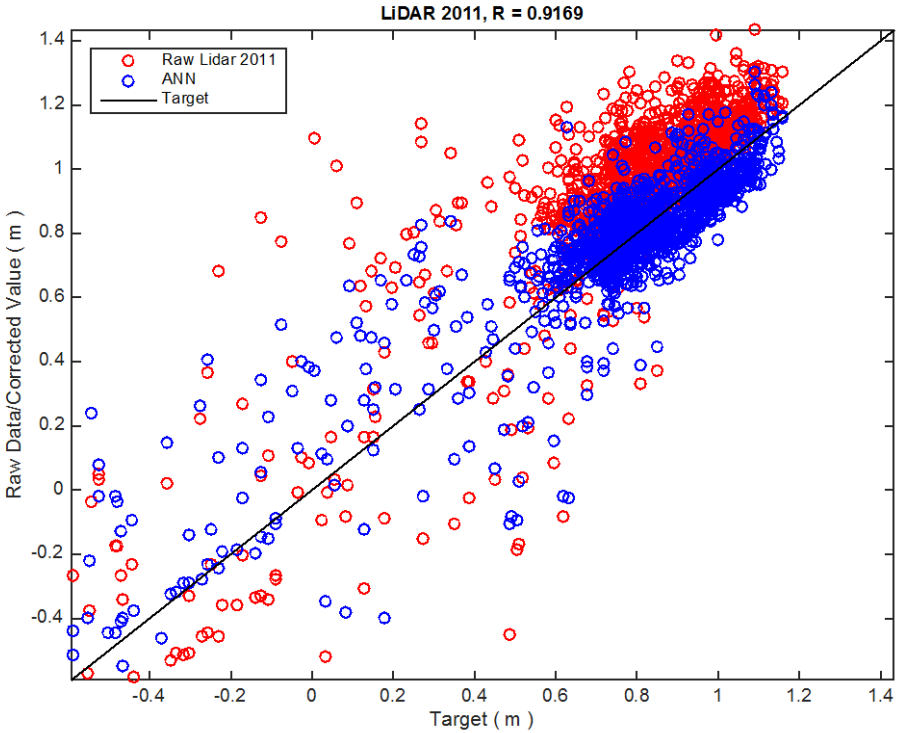


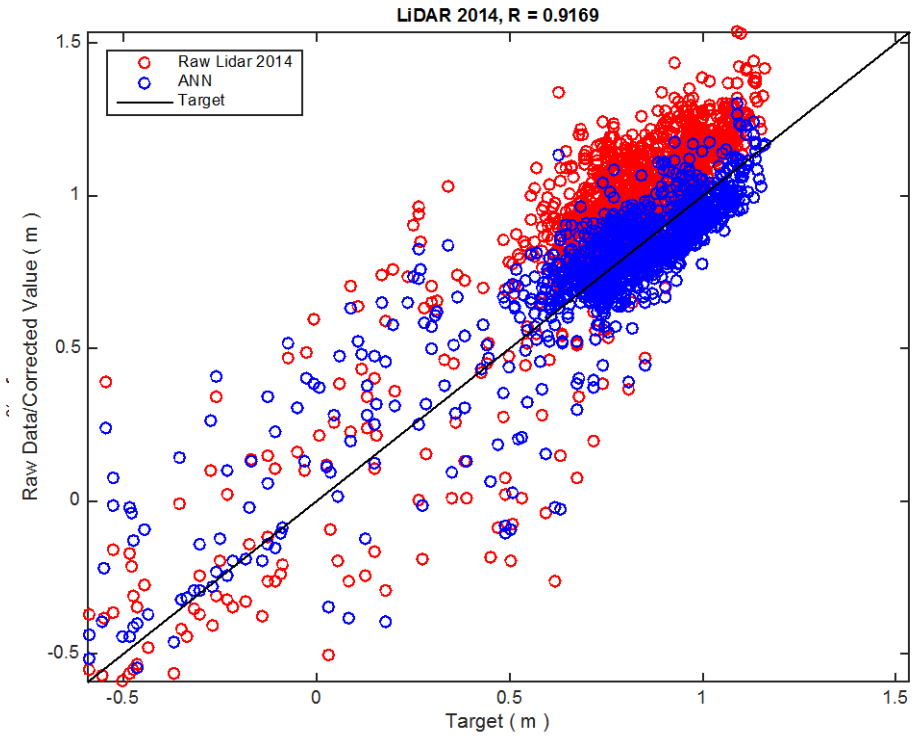



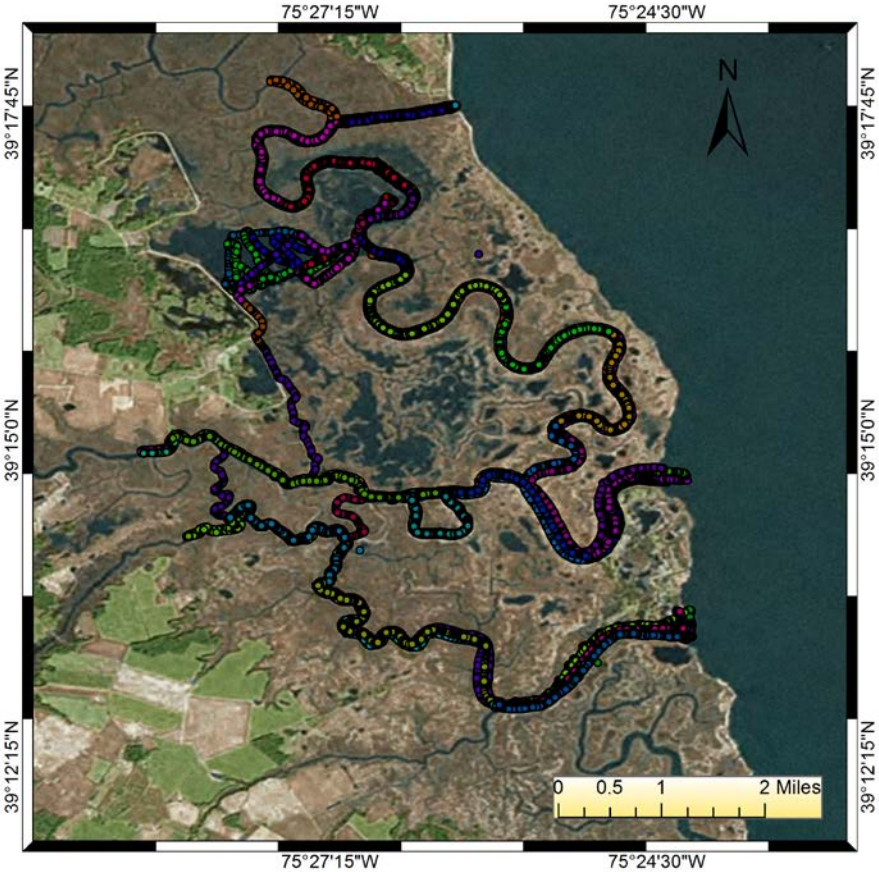



# ARTIFICIAL NEURAL NETWORK (ANN)



# BATHYMETRIC SURVEY (McDowell's Poster)



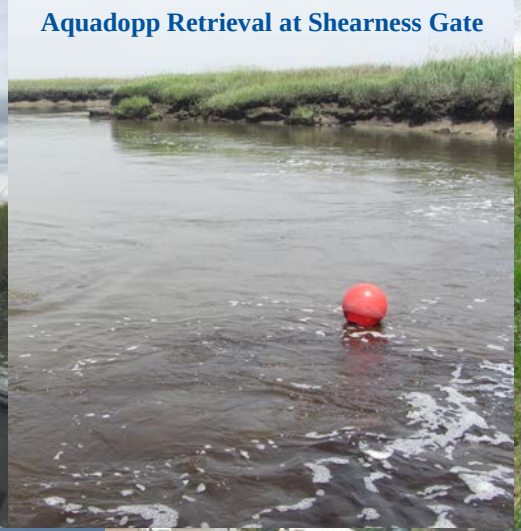

- ✓ **Bathymetric survey along channel center lines and transects**
  - o **Vertical control by 4 DNREC tide gauges and 3 Aquadopp pressure gauges.**
  - o **Local boat elevation by GPS measurement**

- ✓ **Interpolation between bathymetric data and channel shorelines based on 2014 USGS LIDAR topography.**
- ✓ **Checking topography-bathymetry overlaps now**

**Poster Session: Salt Marsh Sediment Accumulation and Morphologic Change at Bombay Hook National Wildlife Refuge.**

# AQUADOPP CURRENT PROFILER

Aquadopp RTK Survey

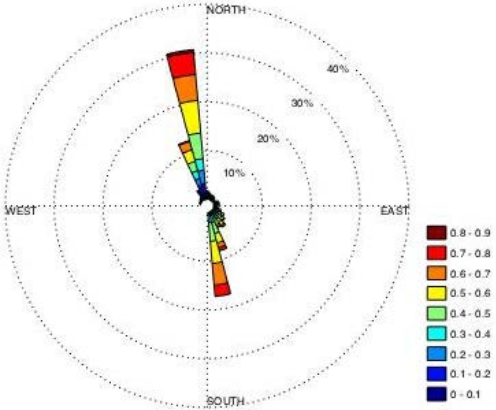

Aquadopp Retrieval at Shearness Gate

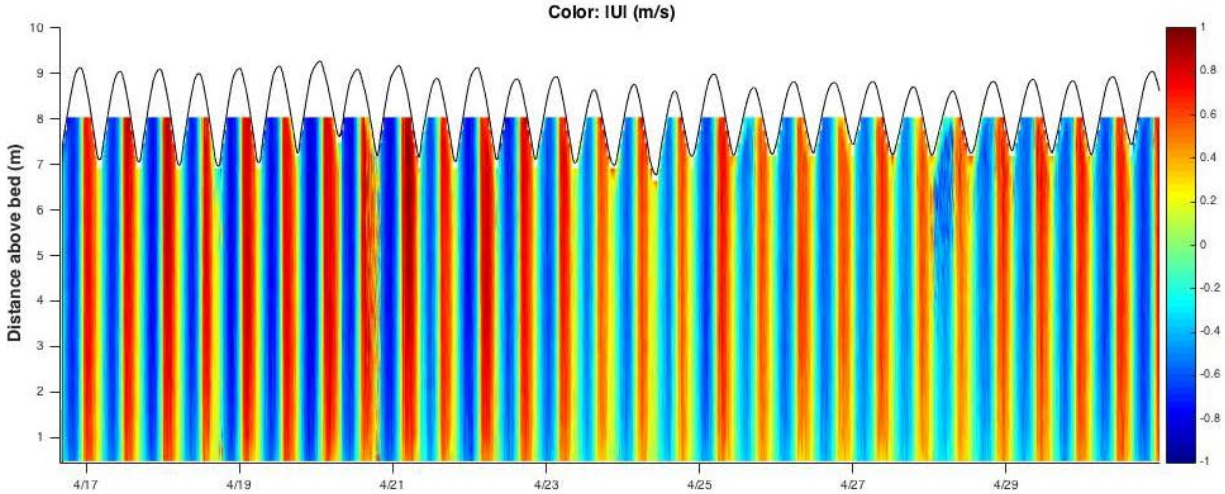
Collected Aquadopps

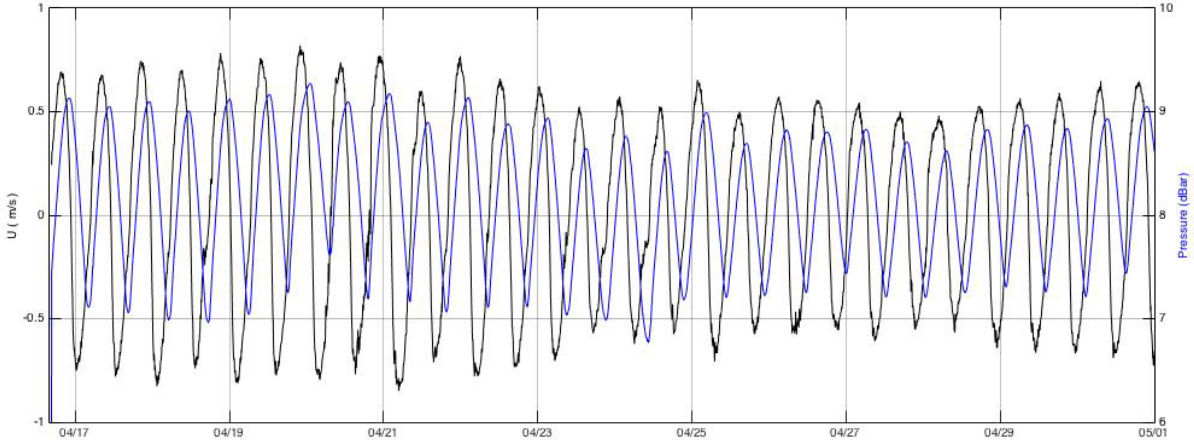
Aquadopp Retrieval

Collected Aquadopp

# Data & Analysis



Deployment of Hobo gauges, channel crossing

Hobo gauges Service, July 23

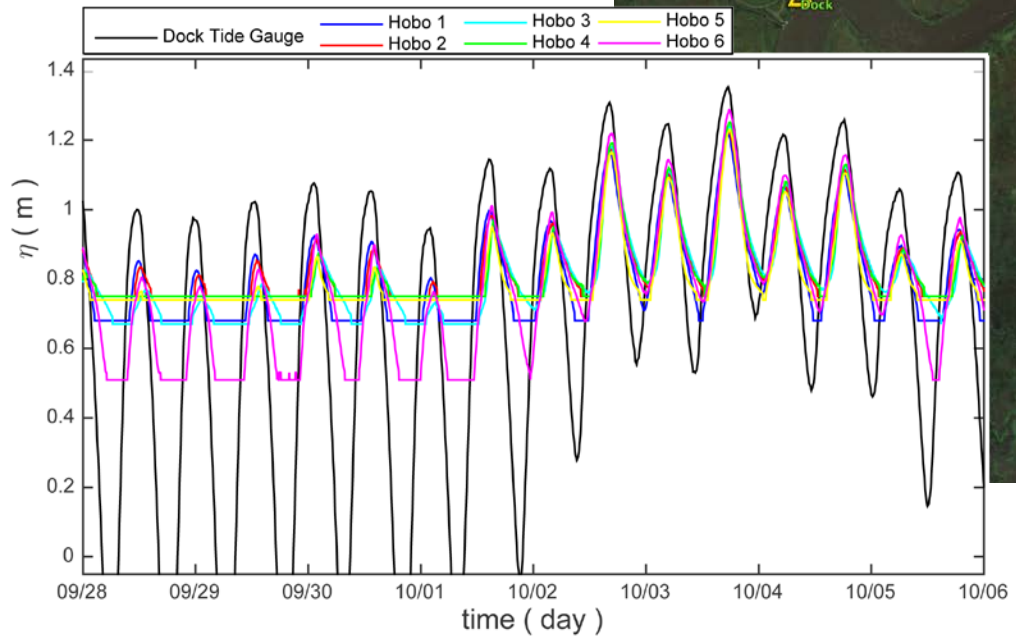
Deployment of Hobo gauges, May 27

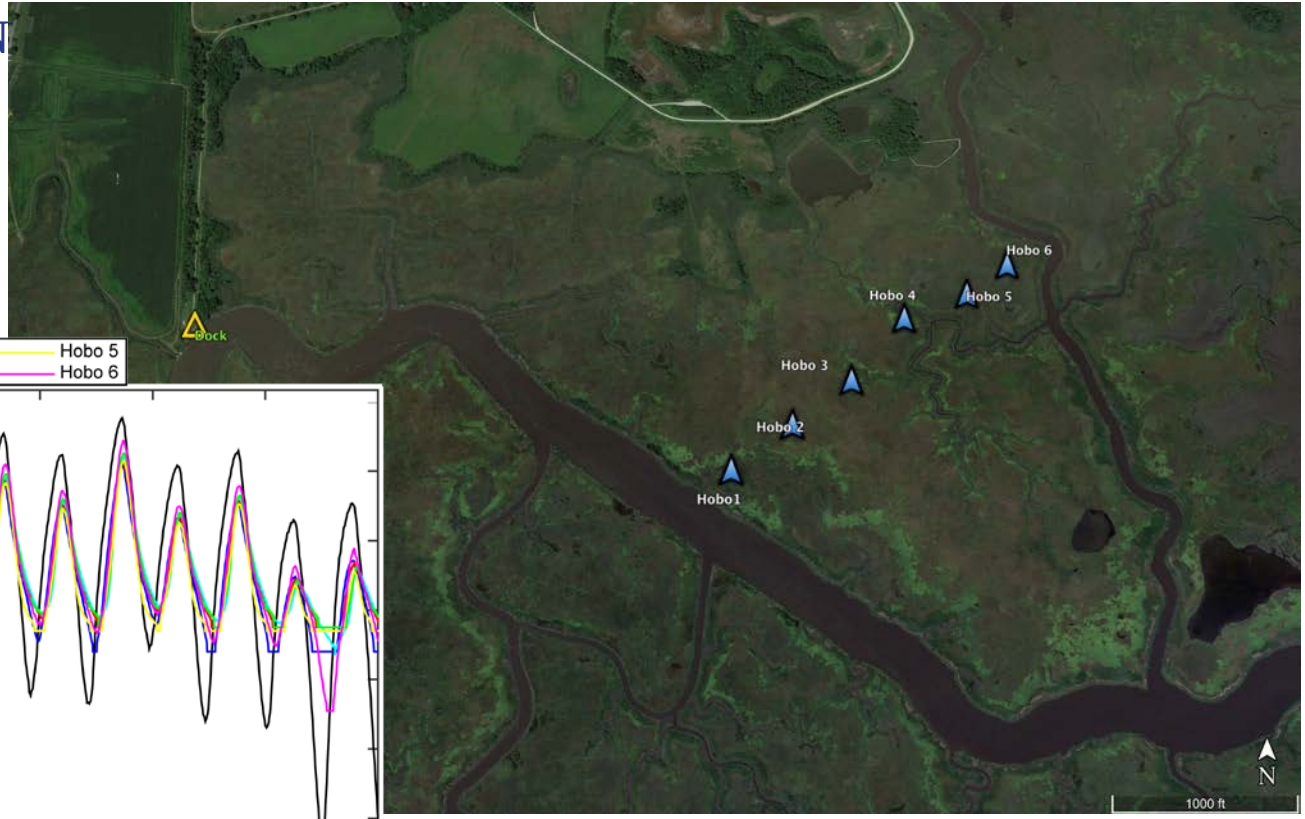
Hobo gauges Service, October 23

Hobo gauges RTK Survey, May 27

Hobo gauges RTK Survey, May 27

# WET & DRYING PATTERN

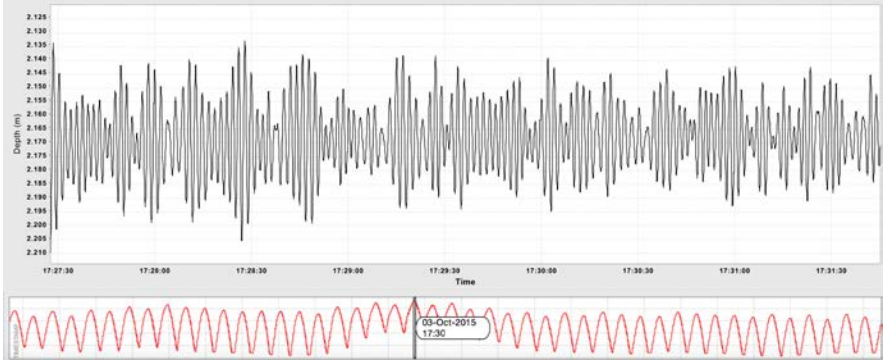


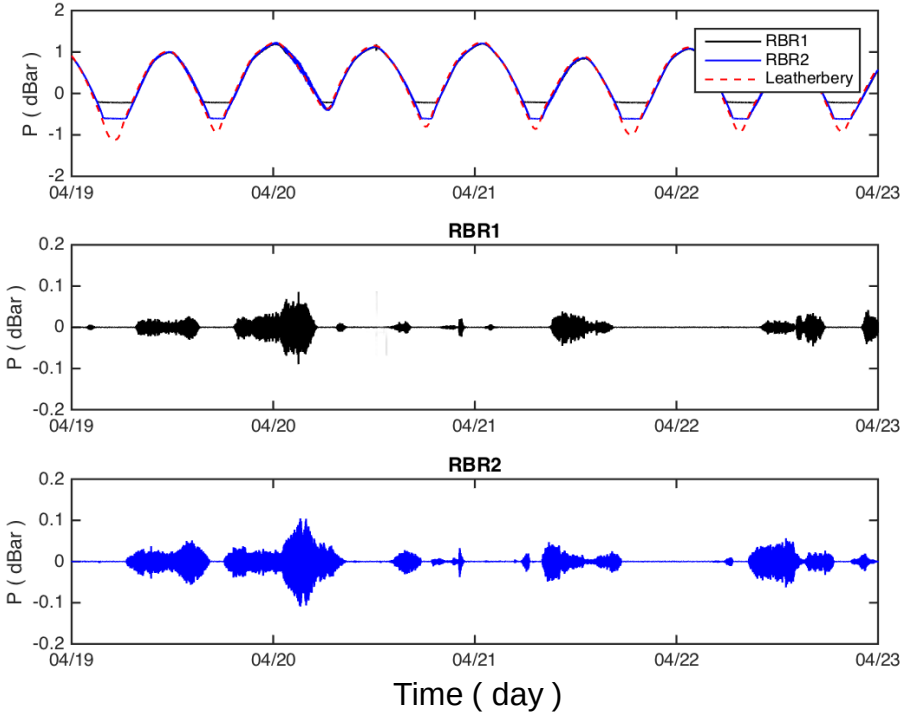
# WIND WAVE MEASUREMENT

**RBR1**
39°16'18.30" N
75°27'49.32" W

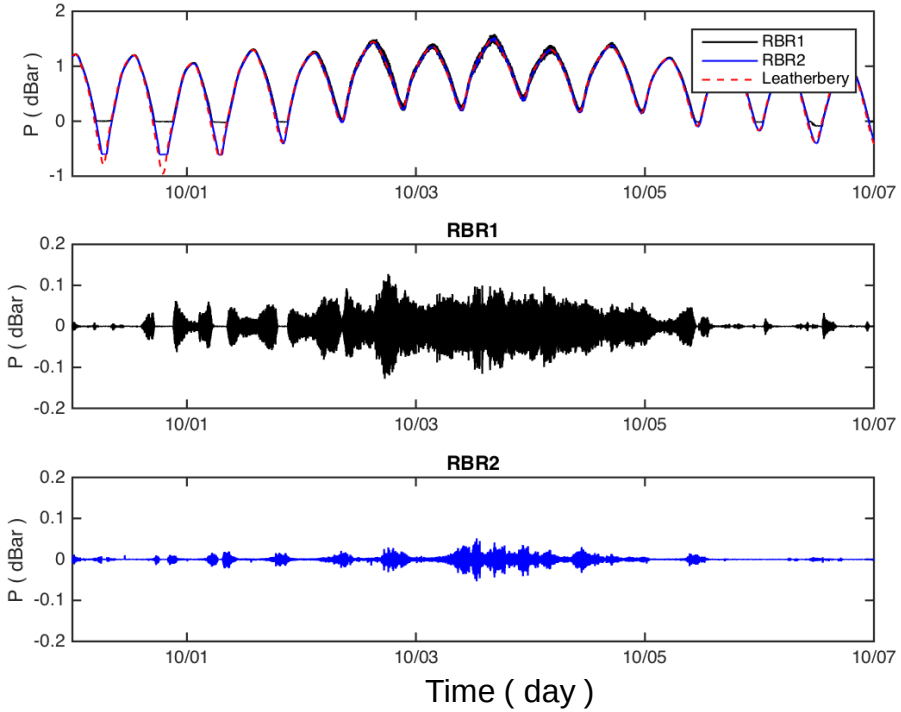
**RBR2**
39°16'39.60"N
75°27'49.56"W



# CALM CONDITION




# STORM CONDITION




**Next Talk: Modeling Wind Waves in a Confined Tidal Flat Area: Bombay Hook National Wildlife Refuge, Delaware**

✓ **Modeling**

- **FVCOM: Nesting in Delaware Bay ROMS model, basic testing**
- **SWAN: Wave prediction in Money Marsh (Deb's Presentation)**
- **Improving modeling efficiency using Subgridding techniques (Shi's Poster)**

✓ **Model-data comparisons so far:**

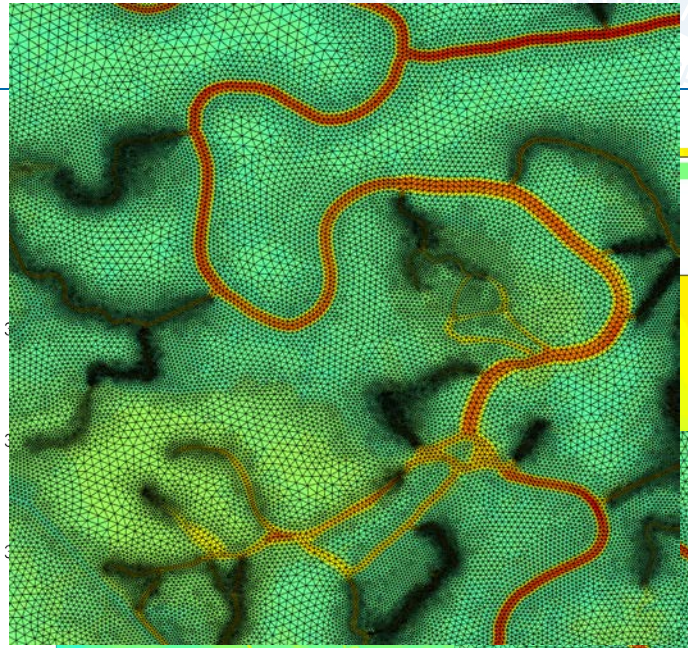
- **What are we looking for?**

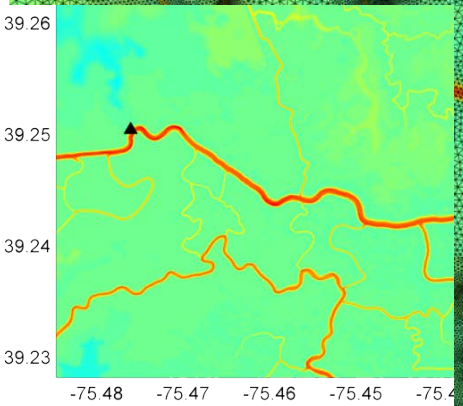
  **Residual flow in system**

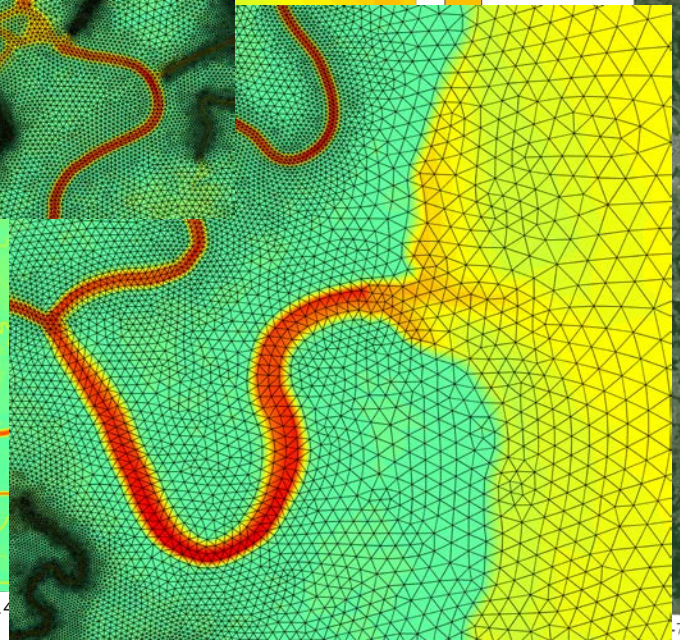
  **Ebb/flood dominance and proxies for sediment flux rates**

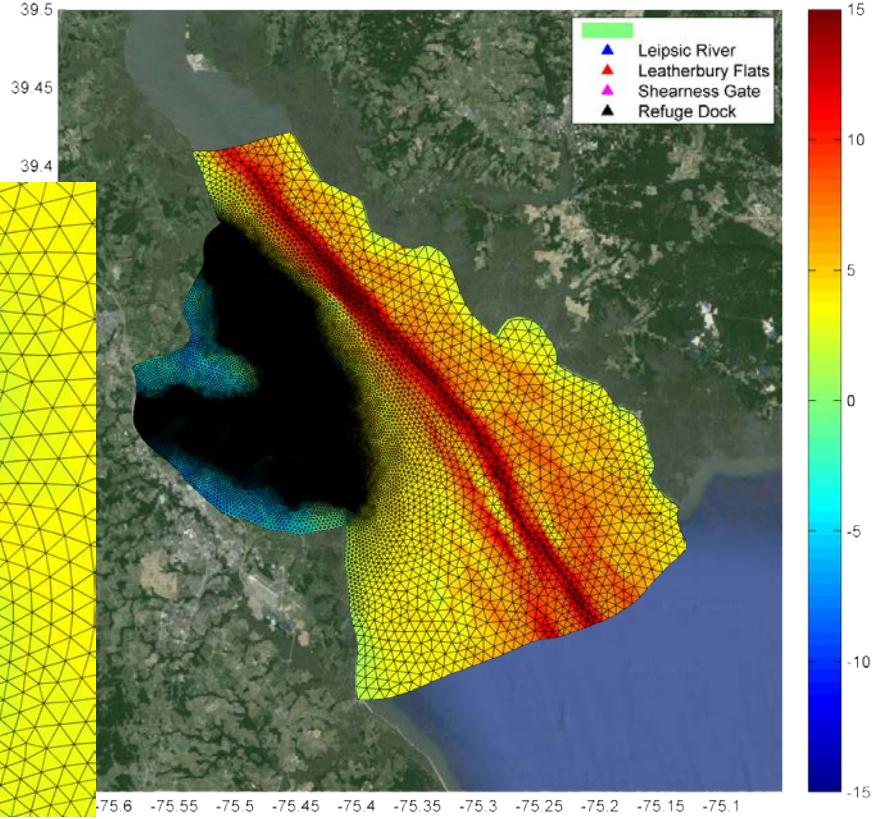
  **Wave energetics in Money Marsh - accelerating erosion?**

# NODES:370629
# CELLS:740776
# FINEST RESOLUTION: 3.5 m

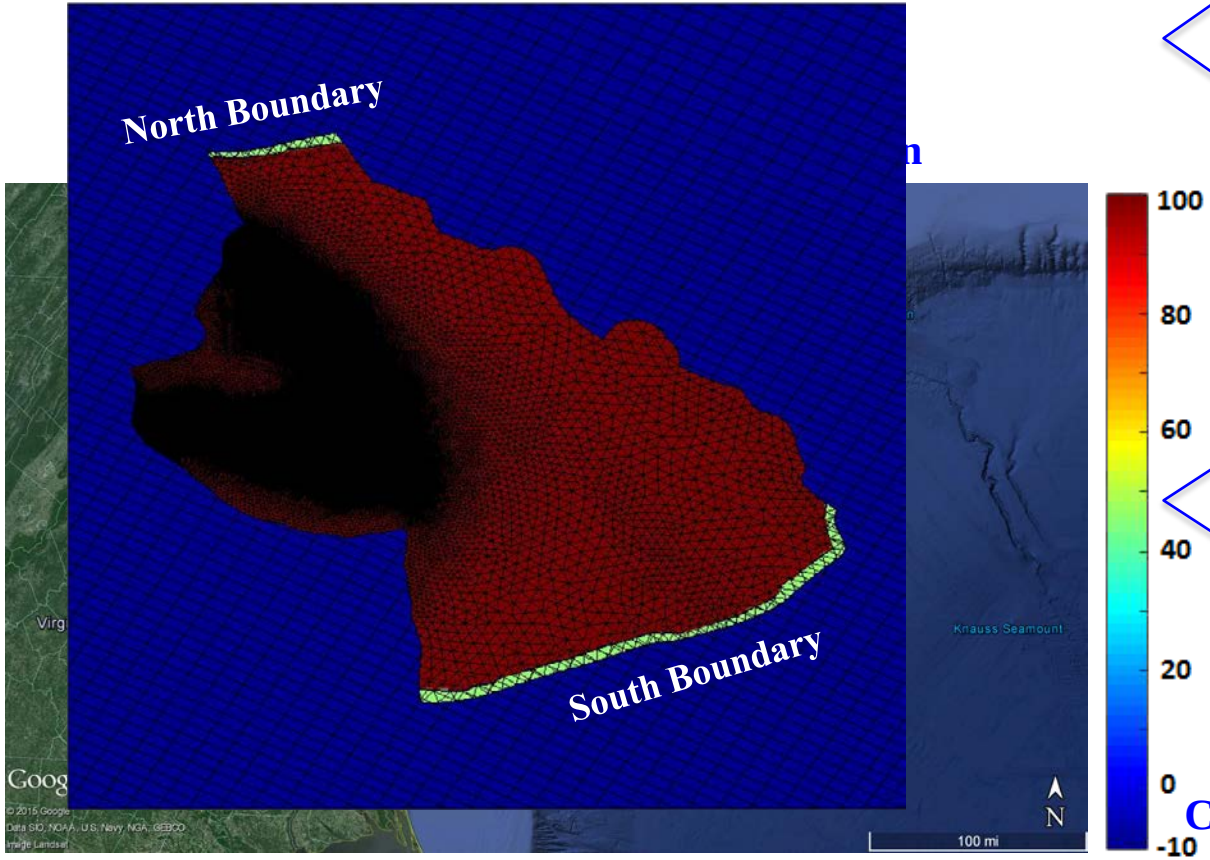




# FORCING BOUNDARY CONDITION




**Regional Ocean Modeling System (ROMS)**

**150 ×300 × 10 structured grid**

**Forcing Boundaries:**

- ✓ Amplitudes and phases for 9 tidal constituents from ADCIRC (M2, M4, M6, K2, K1, N2, O1, and Q1)
- ✓ Subtidal from HYbrid Coordinate Ocean Model or HYCOM)
- ✓ Wind stress calculated from North American Mesoscale Forecast System (NAM-ANL)
- ✓ River discharge from USGS (extrapolated from Trenton gauge)

**Direct Nesting**

Structured grid

Unstructured grid

**Finite Volume Community Ocean Model (FVCOM)**

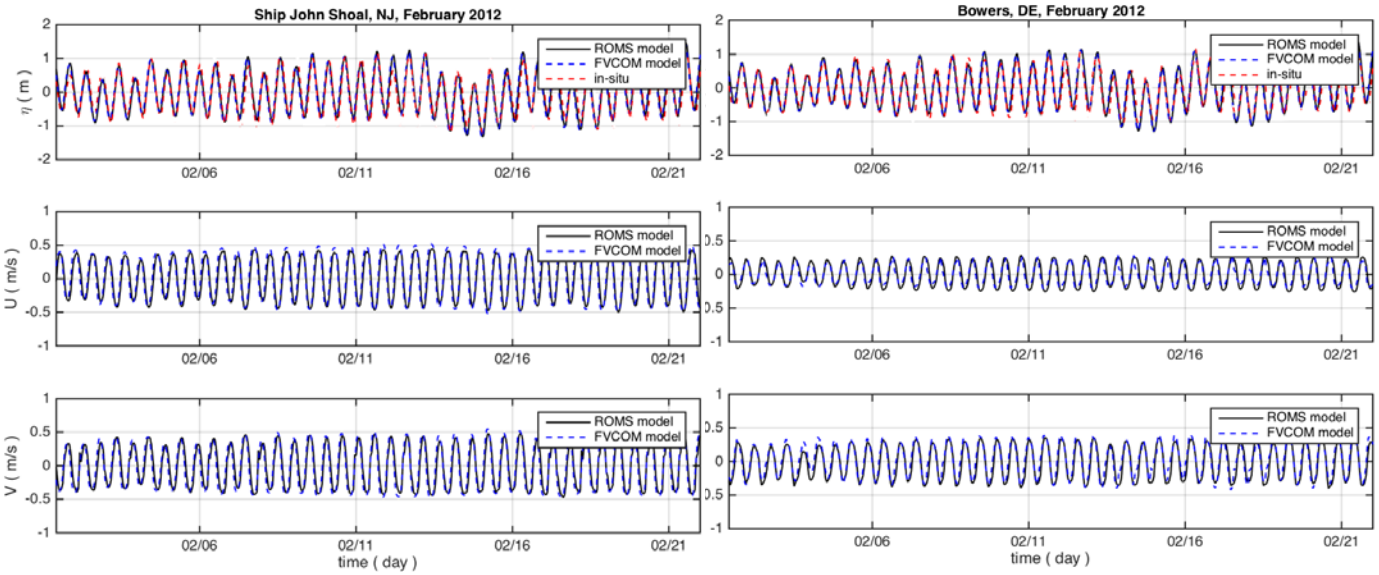
**Nodes: 370629, Cells: 740776**

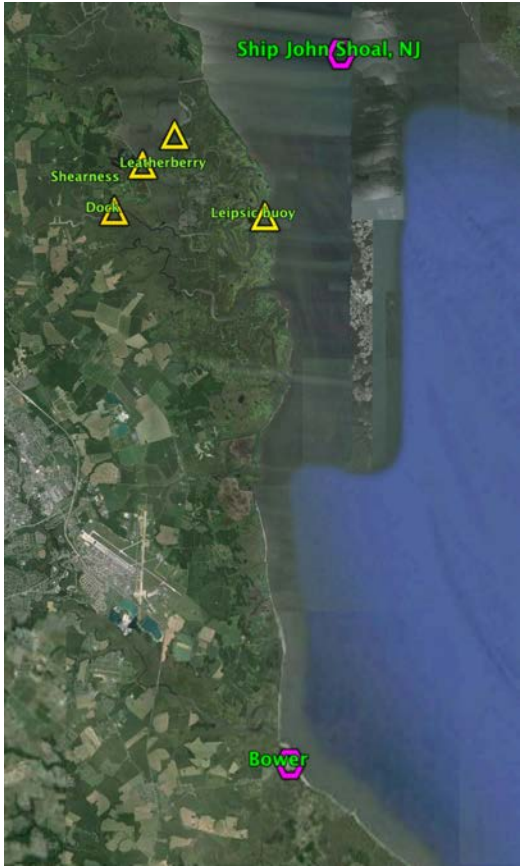
**Forcing Boundaries:**

- ✓ Current and Free Surface Elevation from ROMS
- ✓ wind stress calculated from North American Mesoscale Forecast System (NAM-ANL)

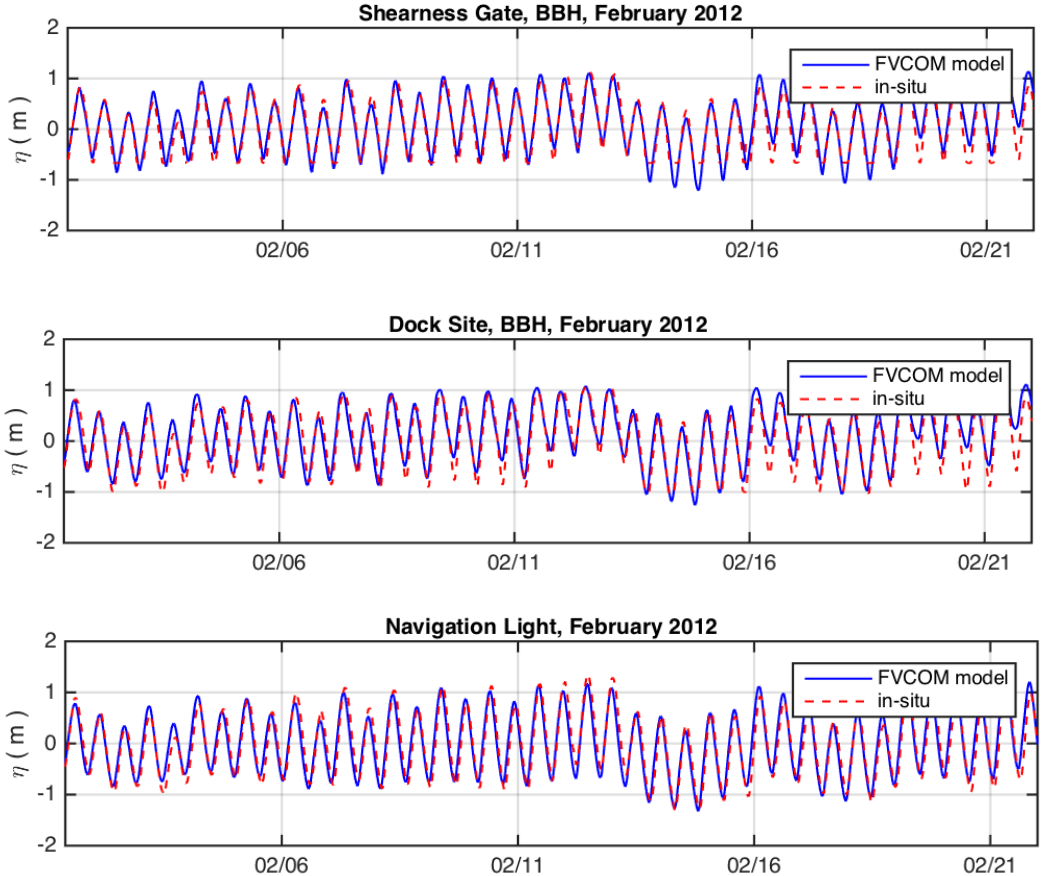
**Common boundary**

# MODEL VALIDATION:
## TIDE GAUGES IN DELAWARE BAY



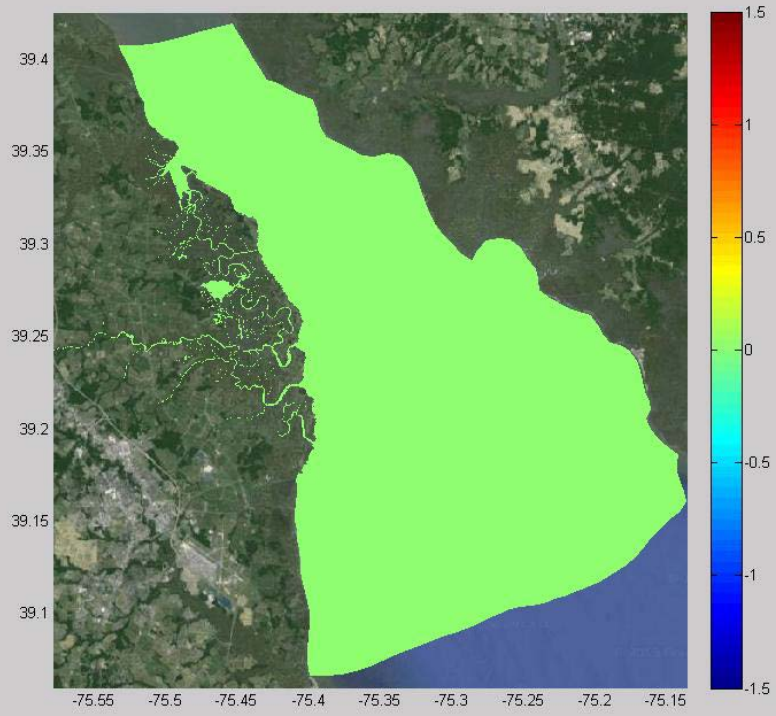



# TIDE GAUGES IN BOMBAY HOOK

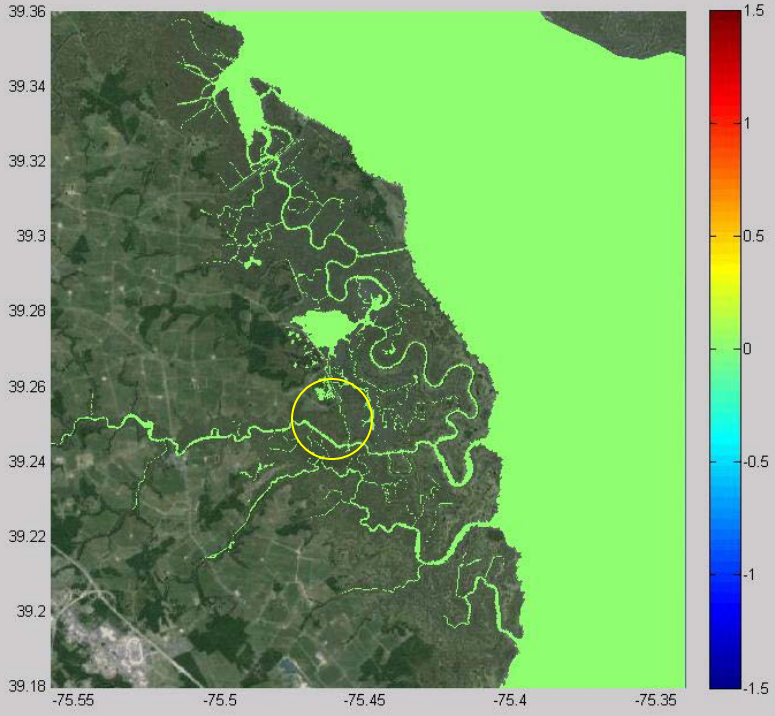


# ELEVATION

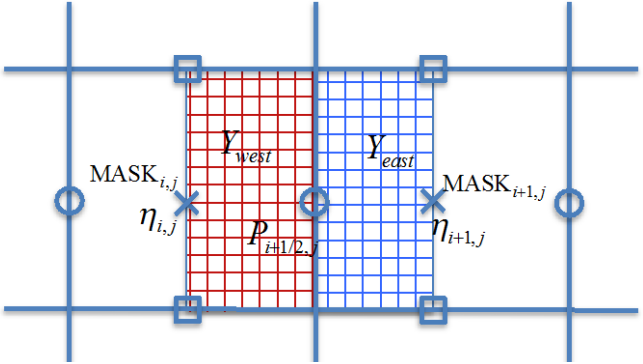
## Zoom Out

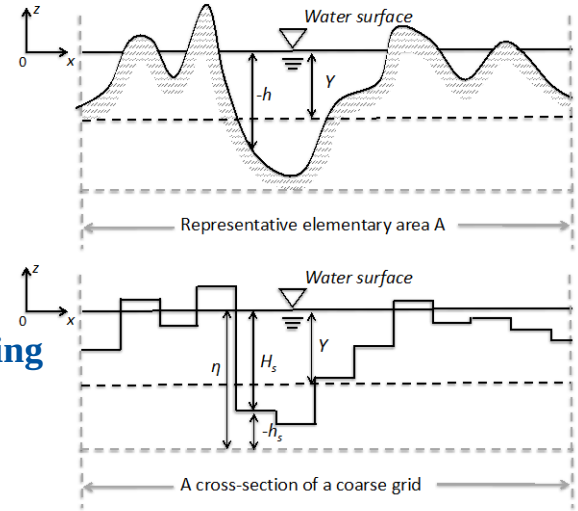



## Zoom In



# Unresolved fine-scale topography and channels …



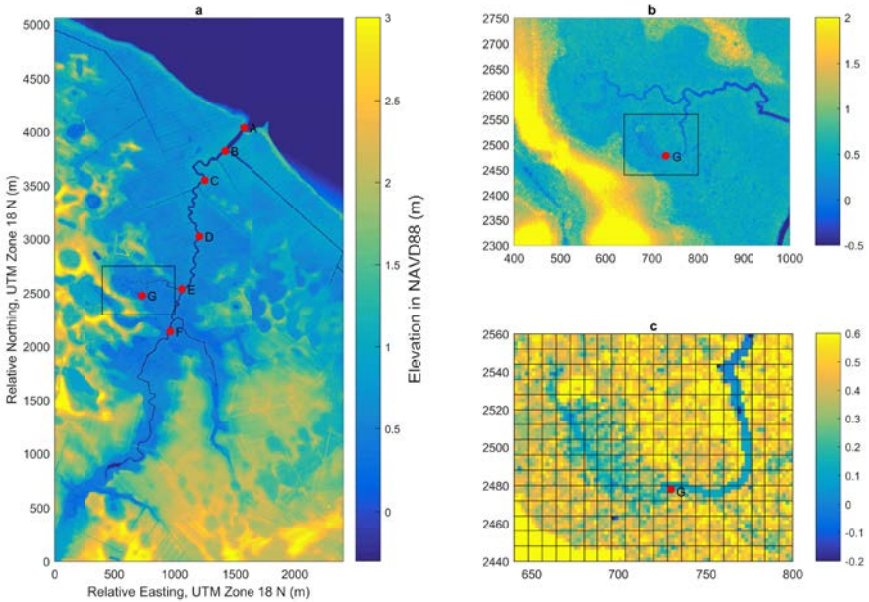



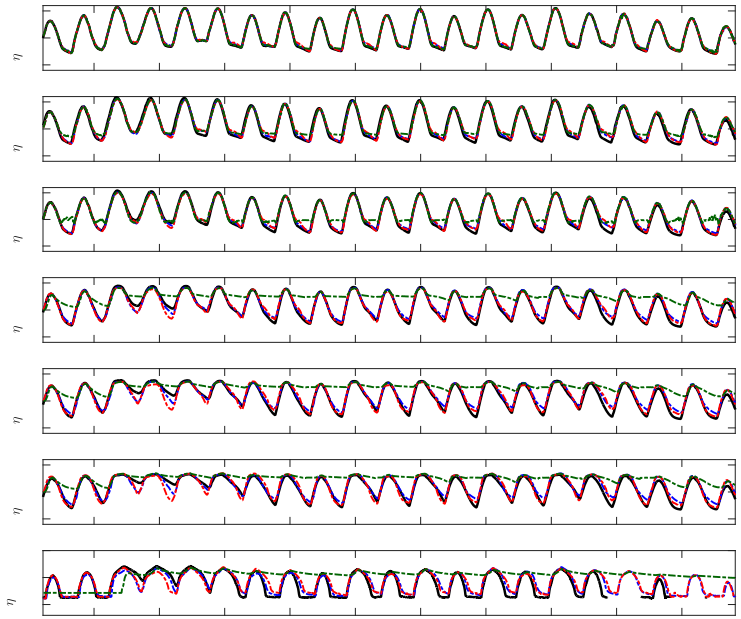

… treated using "subgridding" techniques

**Wu et al, A pre-storage, subgrid model for simulating flooding and draining processes in salt marshes, Coastal Engineering, 2016, 108, 65-78**

**Poster Session: Subgrid Modeling Geomorphological and Ecological Processes in Salt Marsh Evolution in Delaware.**

# Application in Cartesian grid (Brockonbridge Gut, DE, 2013)



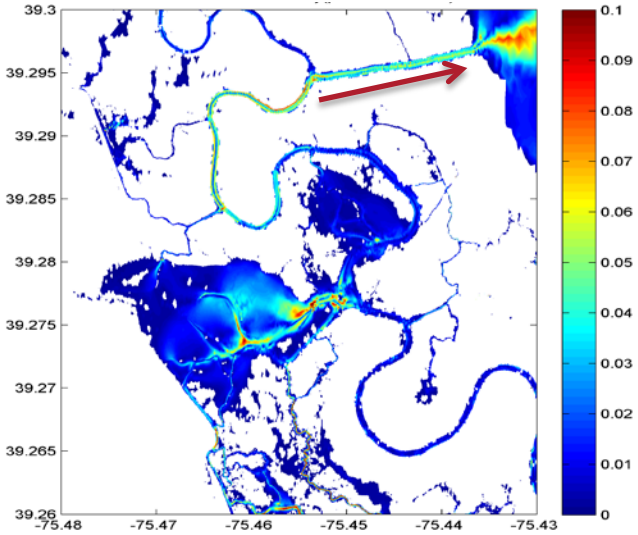




**DEM and instrument locations**

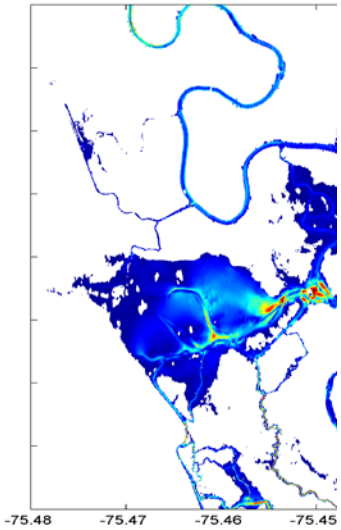
**Model/data comparison**

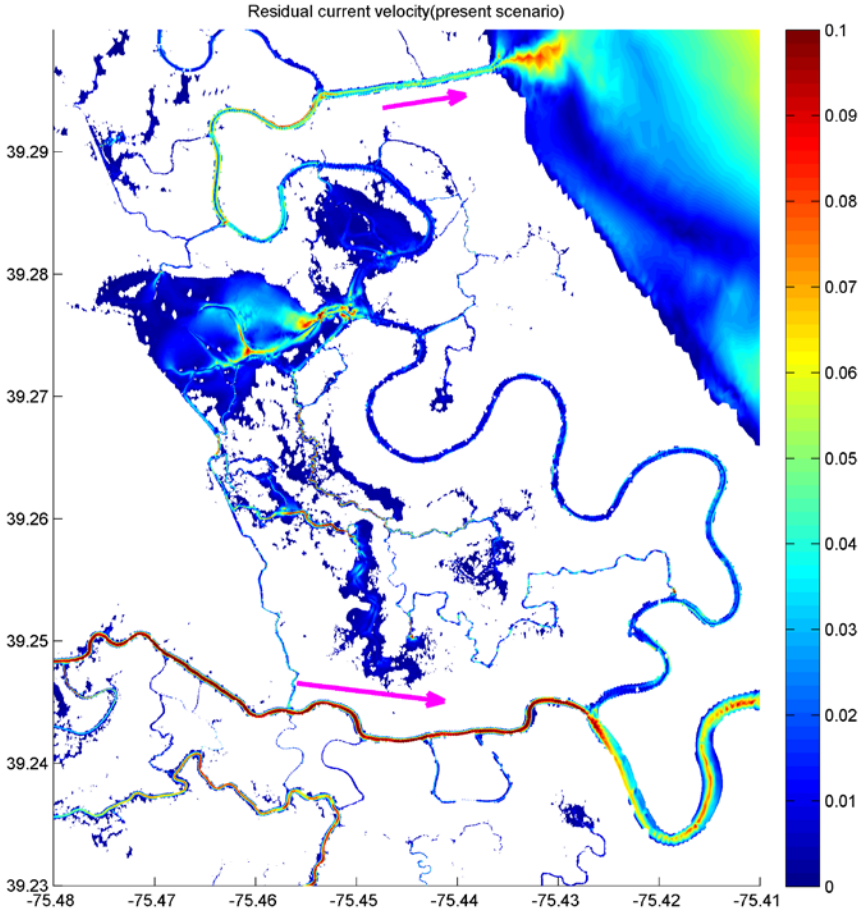
# Residual Current Velocity Magnitude Change

**Present Condition (m/s)**




**Blocked Artificial Cl**

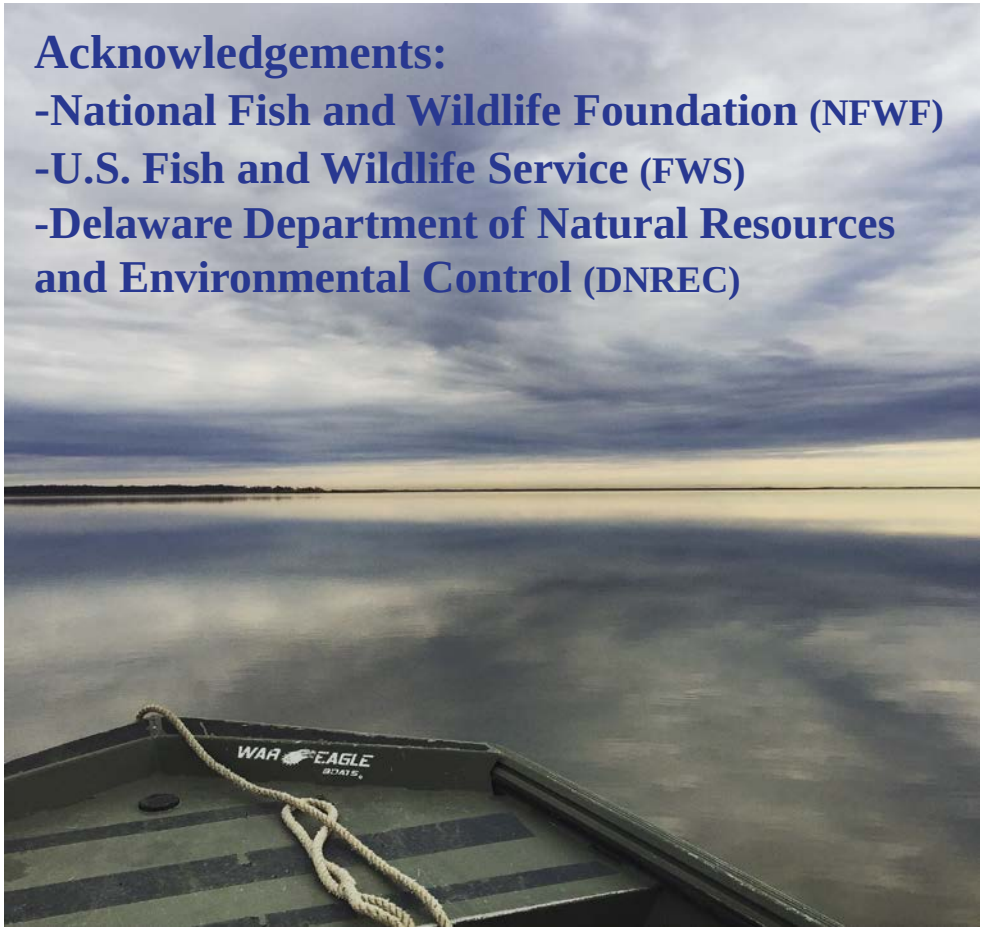


# ONGOING WORK

- Modification of topo-bathymetry data and model DEM
- Considering more complexity in modeling (i.e. spatial variation of bottom friction)
- Model validation for the time period of project measurements
- Long term simulation to reveal net sediment flux patterns
- Examining effects of different scenarios on marsh evolution:
  - Sluice Ditch blockage
  - General channel narrowing/shallowing
  - Balance between marsh accretion rate vs. overall sediment budget for the marsh environment.

**Acknowledgements:**
-National Fish and Wildlife Foundation (NFWF)
-U.S. Fish and Wildlife Service (FWS)
-Delaware Department of Natural Resources and Environmental Control (DNREC)




MONEY MARSH, BOMBAY HOOK REFUGE, April 2015

## THANKS FOR YOUR ATTENTION

SIMON RIVER, BOMBAY HOOK REFUGE, October 2015