

Modeling Tidal Marsh Resilience

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Tidal Shoreline Management Workshop

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Center for
Coastal
Resources
Management

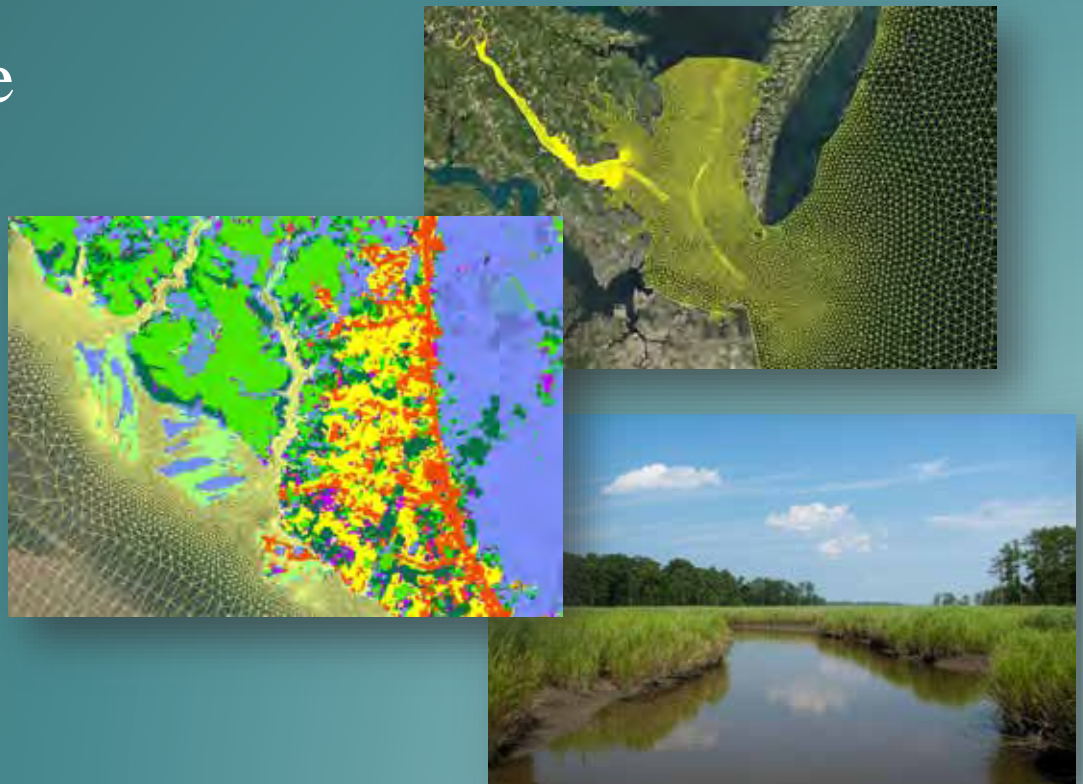
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Photo Credit: Kory Angstadt

Outline

- Background and Motivation
- Tidal Marsh Model (TMM) Overview
- Project Significance



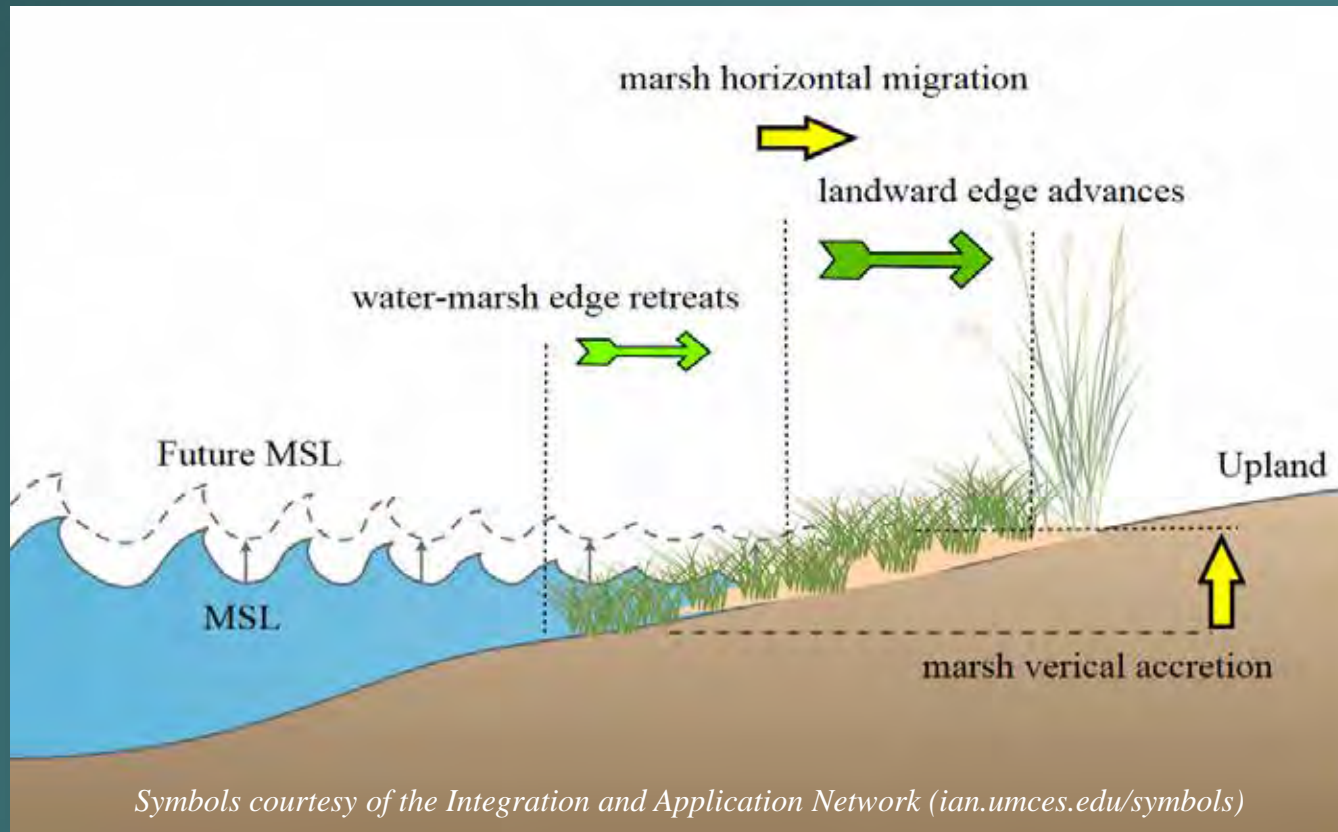
Tidal Marshes & Sea Level Rise

Coastal areas are experiencing a growing threat from sea-level rise and recurrent flooding due to changes in the global climate.



In past decades, special attention has focused on tidal marshes and how they respond to sea-level rise.

Tidal Marshes & Sea Level Rise (SLR)



To keep pace with SLR:

- Marshes accrete vertically
- Marshes migrate horizontally

Tidal Marshes – Sea Level Rise (SLR) & Barriers to Migration

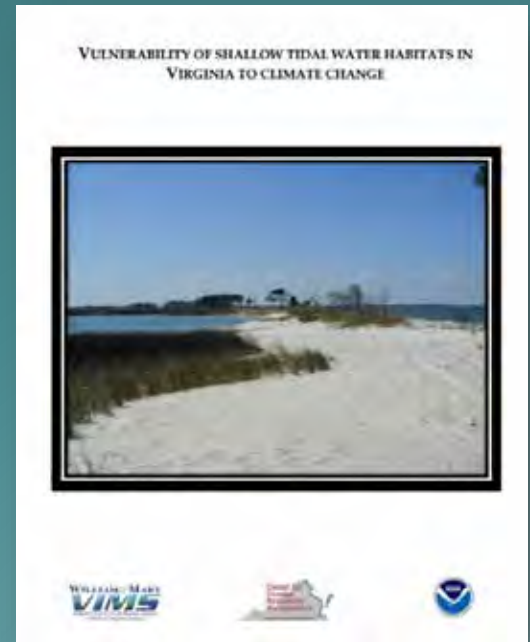
Approximately, **40% of Virginia marshes** are vulnerable to SLR due to adjacent development and topography



High Risk Marsh



Low Risk Marsh



Bilkovic et al. 2009 - Vulnerability of shallow tidal water habitats in Virginia to climate change.

http://ccrm.vims.edu/research/climate_change/index.html

Current Marsh Models

Predicting future wetland sustainability

Large-scale landscape models

(e.g. SLAMM)



Site-specific models

(e.g. MEM)



Marsh Modeling – New Approach: TMM

Develop an **advanced modeling framework** that integrates:

- physical processes
- human components



simulate and assess the evolution and persistence of tidal marshes under different sea-level rise scenarios



Dynamic high-resolution model to evaluate marsh evolution:

TIDAL MARSH MODEL (TMM)

Unique Model Features

TIDAL MARSH MODEL (TMM)



cross-scale model

dynamic rates

barriers to marsh migration



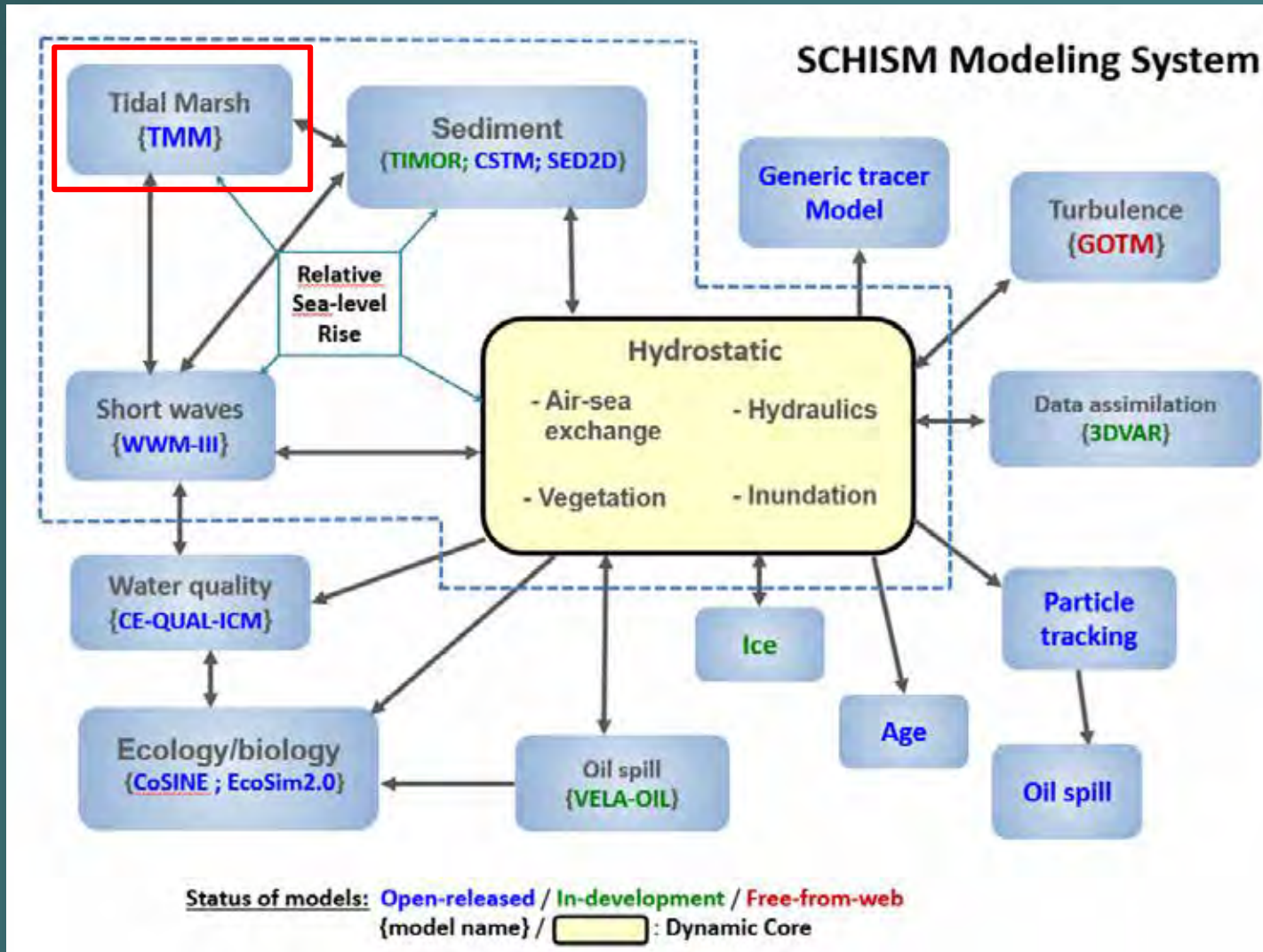
Process at one temporal (e.g. day, year) or spatial (e.g. creek, ocean) scale can interact with processes at another scale.

varying rates in space and time

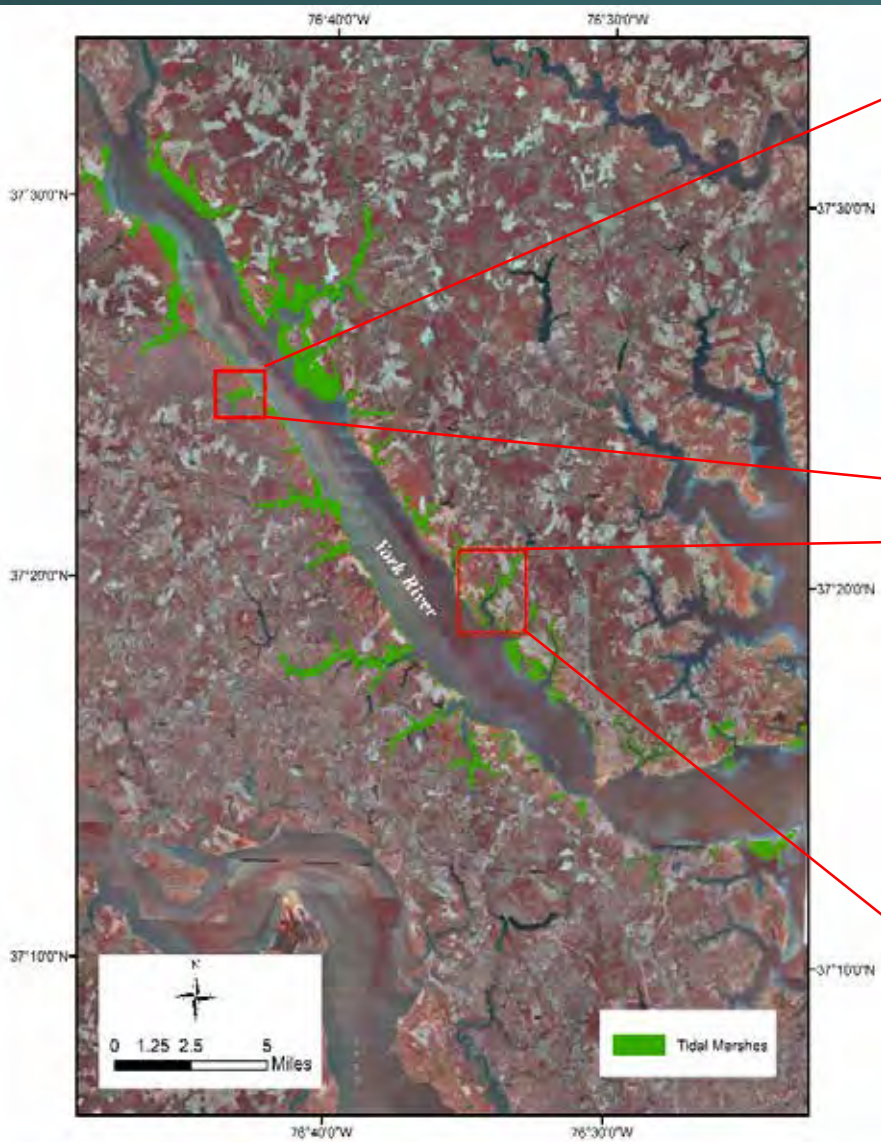
Shoreline erosion protection structures (e.g. bulkhead)

SCHISM

(Semi-implicit Cross-scale Hydroscience Integrated System Model)



Study Area – Carter Creek & Taskinas Creek



TMM code specifications –

TMM simulates **marsh migration** under the joint influence from tides, wind waves, sediment transport, precipitation, and SLR

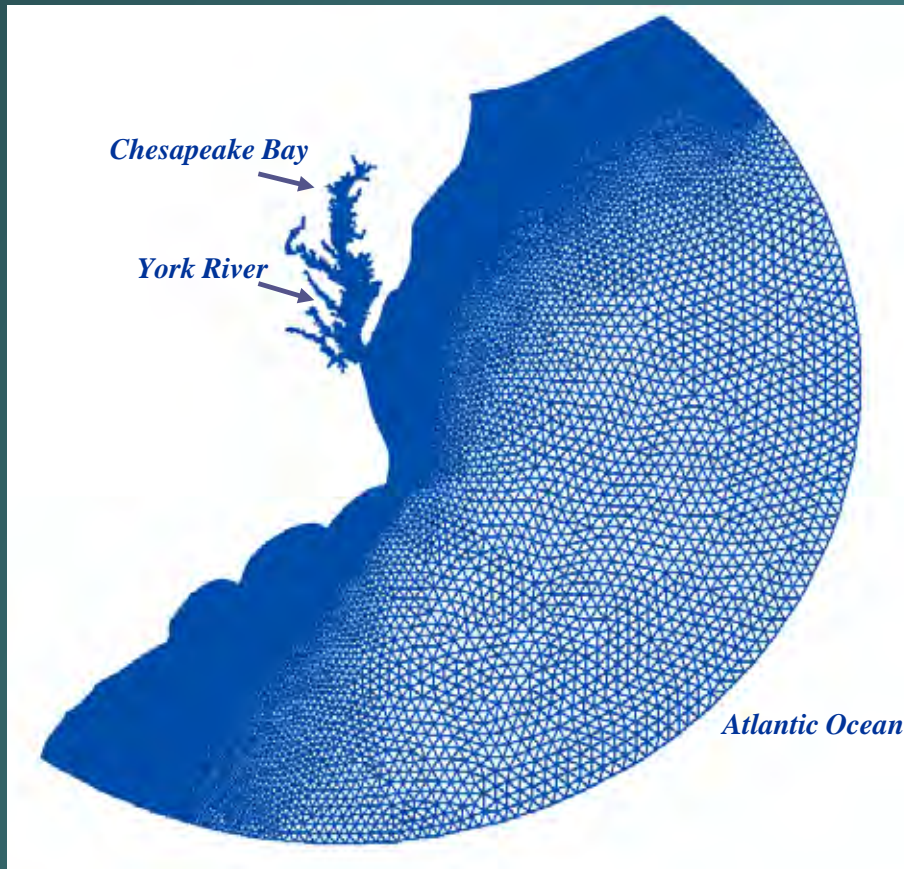


TMM accounts for:

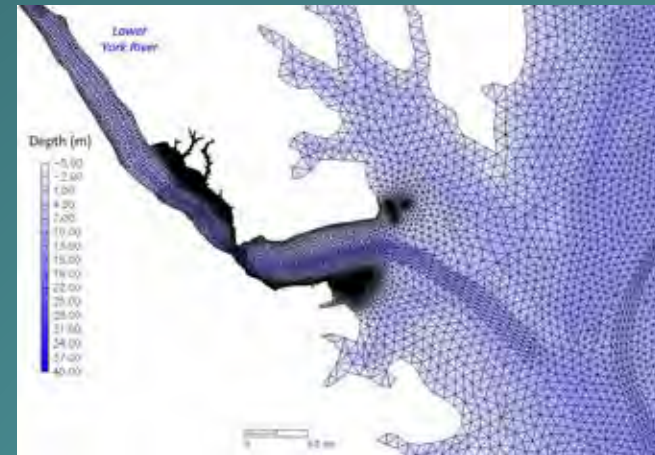
- shoreline bank erosion (water-marsh interphase)
- upland erosion inputs at the upland-marsh edge
- marsh vertical accretion through mineral sediment deposition
- marsh landward migration under changing sea levels with constraints from physical barriers (e.g. ripraps, bulkheads, etc.)

Grid Generation

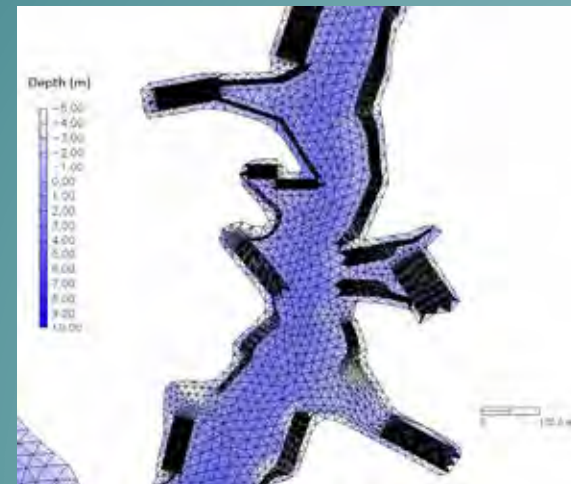
Unstructured grid: uses various combinations of cell shapes and sizes, which allows better fit in areas with complex shoreline geometries



Grid generation software: SMS (Surface-water Modelling System) by Aquaveo.com

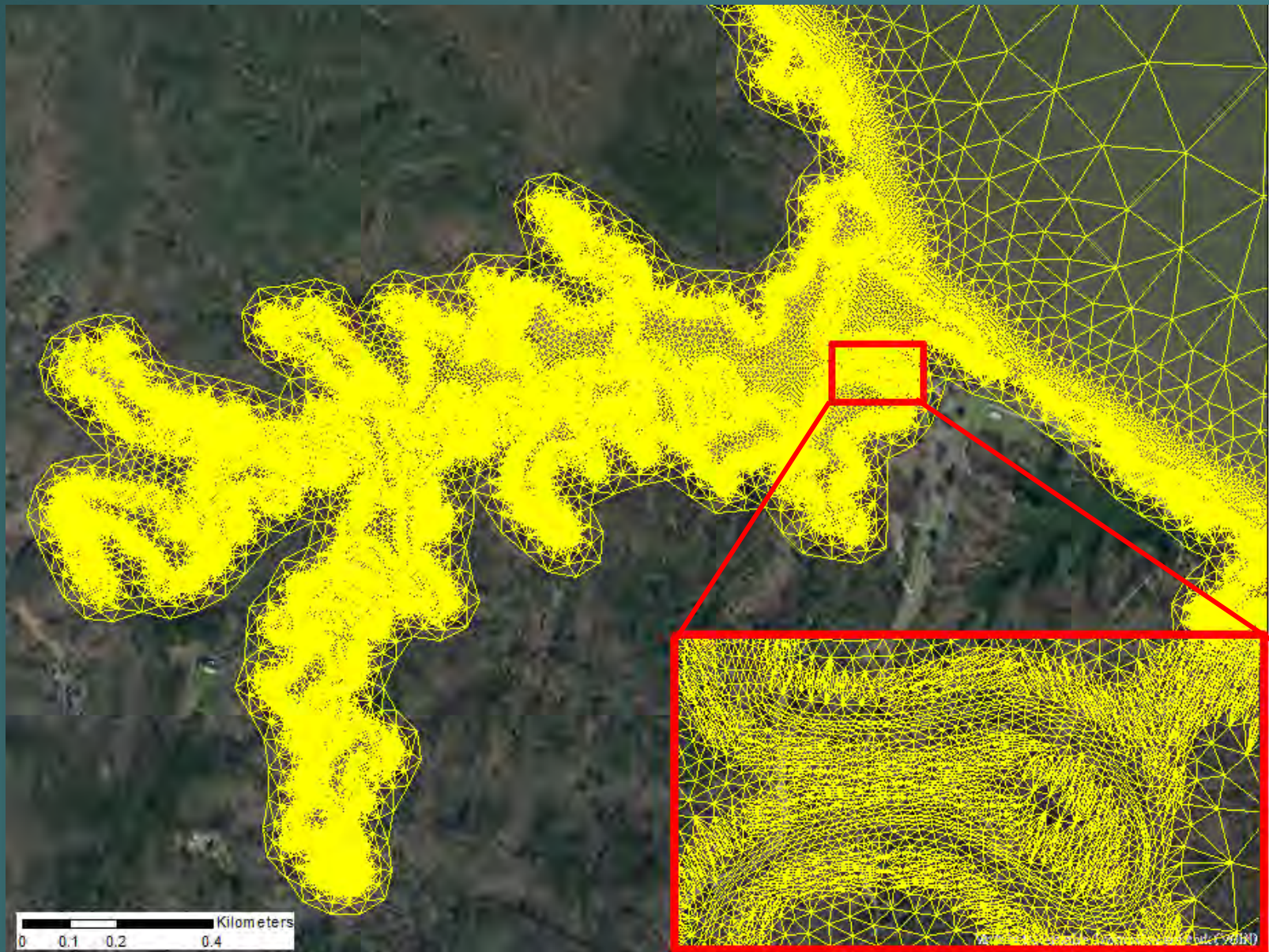


This type of grid allows higher resolution (details) where fine scales are important: **sharp transition**



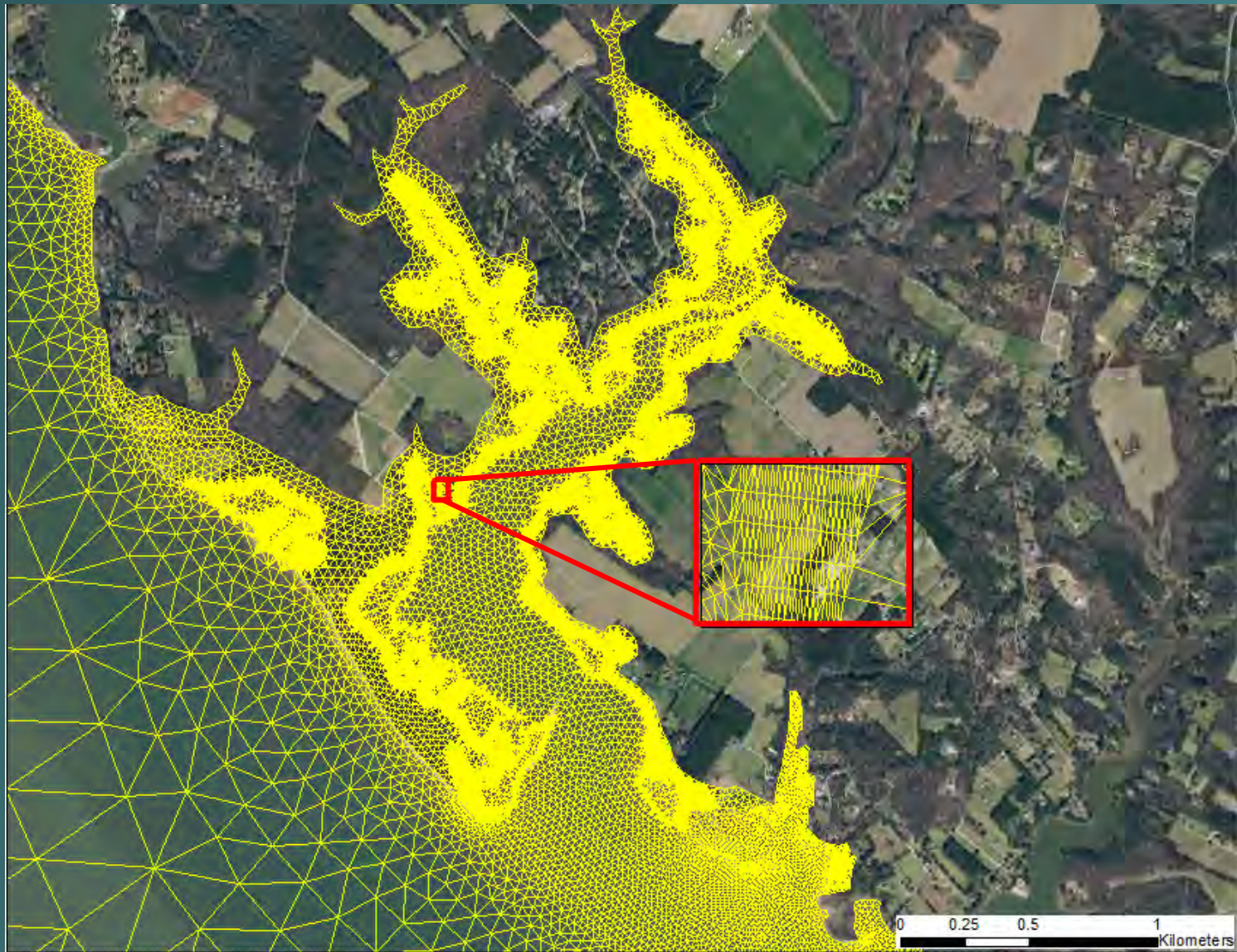
TMM – Model Evaluation

Unstructured Grid - Taskinas Creek



TMM – Model Evaluation

Unstructured Grid - Carter Creek

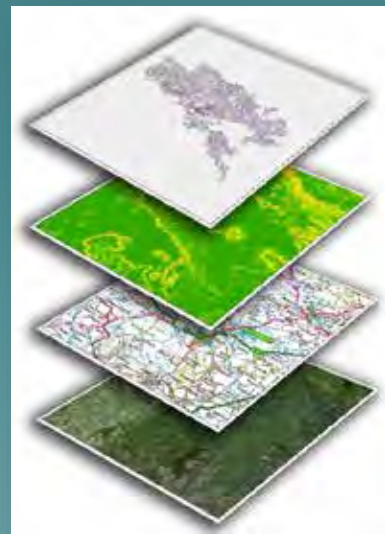




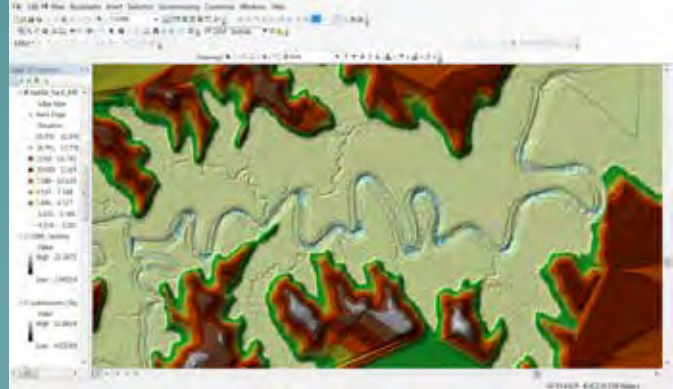
High Performance Computing (HPC) at William & Mary



```
25 [vortex] outputs
24 [vortex] ls
10 dahv.63 31 SED 1.63 local_to_global 0143 windbg_0188
10 elev.61 31 SED 2.63 local_to_global 0144 windbg_0189
10 mrsh.66 31 SED 3.63 local_to_global 0145 windbg_0190
10 pres.61 31 SED 4.63 local_to_global 0146 windbg_0191
10 SED 1.63 31 SED bedd50.61 local_to_global 0147 windbg_0192
10 SED 2.63 31 SED bfrac 1.61 local_to_global 0148 windbg_0193
10 SED 3.63 31 SED bfrac 2.61 local_to_global 0149 windbg_0194
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10 SED bfrac 3.61 31 SED depth.61 local_to_global 0154 windbg_0199
10 SED bfrac 4.61 31 wind.62 local_to_global 0155 windbg_0200
10 SED brough.61 31 wwm 10.61 local_to_global 0156 windbg_0201
10 SED batress.61 31 wwm 1.61 local_to_global 0157 windbg_0202
10 SED depth.61 31 wwm 16.61 local_to_global 0158 windbg_0203
10 wind.62 31 wwm 3.61 local_to_global 0159 windbg_0204
10 wwm 10.61 31 wwm 7.61 local_to_global 0160 windbg_0205
10 wwm 1.61 31 zcor.63 local_to_global 0161 windbg_0206
10 wwm 16.61 32 dahv.62 local_to_global 0162 windbg_0207
10 wwm 3.61 32 elev.61 local_to_global 0163 windbg_0208
10 wwm 7.61 32 mrsh.66 local_to_global 0164 windbg_0209
10 zcor.62 32 pres.61 local_to_global 0165 windbg_0210
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11 elev.61 32 SED 2.63 local_to_global 0167 windbg_0212
11 mrsh.66 32 SED 3.63 local_to_global 0168 windbg_0213
11 pres.61 32 SED 4.63 local_to_global 0169 windbg_0214
11 SED 1.63 32 SED bedd50.61 local_to_global 0170 windbg_0215
11 SED 2.63 32 SED bfrac 1.61 local_to_global 0171 windbg_0216
```



TMM outputs: files can be exported to the GIS environment for further spatial analysis and visualization (e.g. interactive map viewers).



TMM Results - Marsh Boundary Evolution



TMM Results

- Model outputs present a strong agreement with field observation
- Model results show that the TMM successfully captures processes important for marsh evolution:
 - marsh inundation frequency
 - wave energy attenuation by marsh plants
 - erosion-deposition patterns around coastal structures
 - marsh landward migration



SUMMARY - Project Significance

TMM will overcome many of the limitations current marsh models present:

Current Models

scaling problems

constant rates

exclusion of
hardened shoreline
structure impacts



TMM

“cross-scale” model
(increased resolution)

dynamic modeling
(varying rates in space and time)

**highly resolves marsh
landward migration**

SUMMARY - Project Significance

- Build a better foundation/framework to model marsh evolution



Highly resolved outputs will allow coastal planners to more accurately identify the potential future location of marsh habitats where protection and restoration activities can be focused to increase tidal marsh resilience.

Thanks!

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